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THE BLACK SWAMP: A STUDY IN HISTORICAL GEOGRAPHY

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INTRODUCTION

NORTHWESTERN Ohio, particularly that portion once covered by the Black Swamp, stands out in the early annals of the "westward movement" because it was so slow to be settled. Lands farther north, south, and west were settled first. Why was northwestern Ohio avoided? How was it finally settled? How was the landscape transformed so that it became an integral and prosperous section of the vast region now known as the Corn Belt? These are the principal problems and questions with which this study of the historical geography of the Black Swamp of northwestern Ohio is concerned.

The Black Swamp is no more, but until it was drained late in the nineteenth century it was a feature to be contended with by all who sought to settle in or travel through northwestern Ohio. Soldiers during the War of 1812 and, afterward, immigrants to Michigan and northern Indiana were unwilling witnesses to its terrors.

Swamp and marsh land of varying degrees of wetness covered nearly all of northwestern Ohio, which may be defined as that area lying north of the Treaty of Greenville line and west of the old Connecticut Reserve.

The Black Swamp, an irregular strip about thirty miles wide, lying parallel to the east bank of the Maumee River from Lake Erie southwest to New Haven, Indiana, was some 1,500 square miles in extent (Fig. 1). It was the largest swamp in northwestern Ohio and, with respect to the westward tide of settlement, lay in the most obstructive position.

Specifically, the Black Swamp is that portion of the lake plain of northwestern Ohio which at the time of settlement was nearly one continuous region of standing water or so wet as to ooze water when walked upon in all seasons except the very driest. Where occasional discontinuous sand ridges and rock outcrops rise above the general level of the terrain and comprise relatively dry and well drained land, they have been included as part of the Black Swamp because their extent is not great enough to interrupt the over-all continuity of swamp land. On the other hand, where major interruptions in the terrain, such as continuous beach ridges or mo-

raines, beyond which only a few scattered sloughs and swales are to be found, such sloughs and swales have not been included as part of the Black Swamp. In many places the swamp boundary is, indeed, difficult to determine with great accuracy, and a line has been drawn midway through the zone of doubt. The area of the morass varied seasonally as well as annually with changes in precipitation; consequently various observers have assigned various dimensions to it.

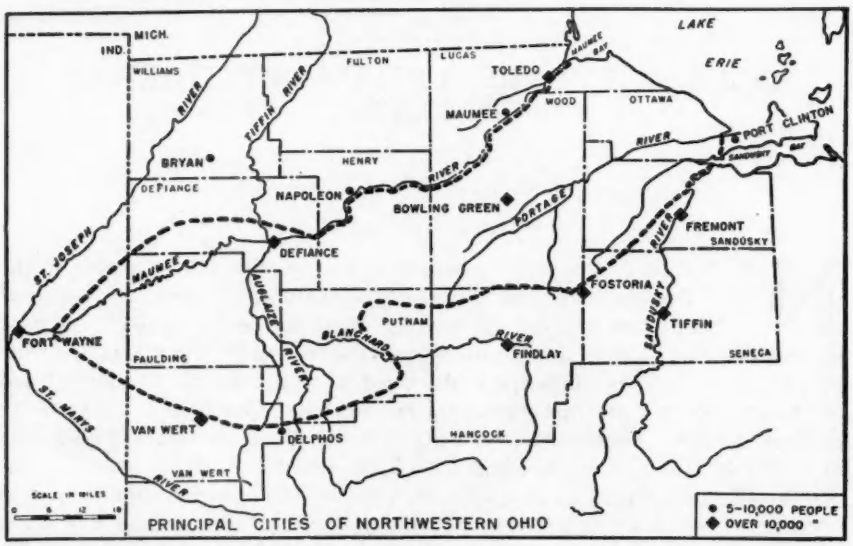

FIG. 1. Northwestern Ohio in 1950 showing limits of the Black Swamp and principal cities. Compare with Fig. 2.

THE BACKGROUND OF AMERICAN SETTLEMENT IN NORTHWESTERN OHIO

Prior to the Treaty of Greenville in 1795, all of northwestern Ohio together with most of Michigan and Indiana was Indian territory. The region had been penetrated by the French and English, but the areas of penetration were for the most part confined to two long established routes between Lake Erie and the Ohio and Mississippi Rivers. The best known of these routes was the Maumee-Wabash Trail along the Maumee and Wabash Rivers. The low and narrow divide between the Great Lakes and Mississippi drainage systems made only a short portage necessary between the headwaters of the two rivers. The other route was the Scioto Trail which followed the Sandusky River, crossed the above-mentioned divide, and continued down the Scioto River to the Ohio. Thus the Black Swamp was bracketed on the east and on the west by important routes of north-south travel (Fig. 2). The early French and English trading posts and forts as well as the early Indian villages which lay along the trails were in most cases the forerunners to later permanent American settlements.

The first positive evidence of Indian villages along the Ohio portion of the Maumee dates back to about the middle of the eighteenth century and to the period of Pontiac's uprising.[1] During this time there were villages near the lower rapids of both the Maumee and Sandusky Rivers and near the site of modern Upper Sandusky. There were also villages on the Auglaize and its tributary the Blanchard. The exact location of some of these villages is, indeed, difficult to determine, but it is not so important as their general location (Fig. 2). The latter is sufficient to

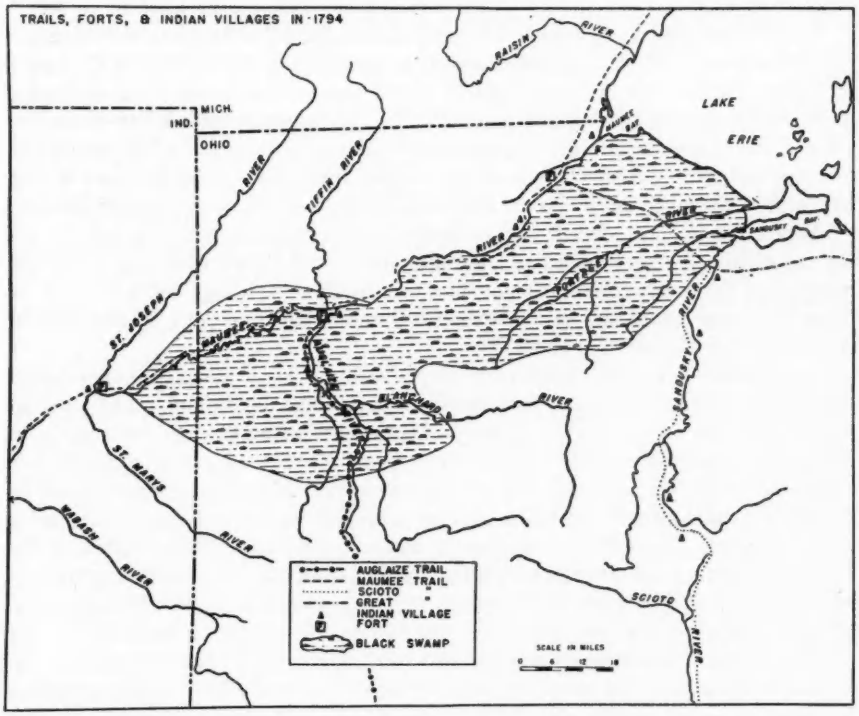

FIG. 2. Principal trails, Indian villages, and forts of the Black Swamp region in 1794.

reveal the manner in which the villages fringed the Black Swamp on the east, south, and west. Here is the clue to the initial pattern of white settlement in northwestern Ohio.

The diary of David Zeisberger, a Moravian missionary who traveled through northwestern Ohio and southeastern Michigan in 1761–82, provides an early description of the Black Swamp and the lake plain of which it was a part. He writes, after leaving the Sandusky River for Detroit in October, 1791, of the "deep swamps

[1] H. Peckham, *Pontiac and the Indian Uprising* (Princeton, New Jersey: Princeton University Press, 1947), p. 32.

and troublesome marshes," the many miles "where no bit of dry land was to be seen, and the horses at every step wading in the marsh up to their knees. . . ."[2] The thirty to thirty-five mile trip from the Sandusky to the Maumee had taken Zeisberger two and one-half days. A later entry in his journal describes the flatness of the country ". . . not so much flooded . . . yet wet and swampy."[3] Zeisberger also noted the clayey nature of the soil, "which is one reason why the water remains standing," and the dominant vegetation of "beech-swamp or ash, linden, elm, and other trees such as grow in wet places"; even many oak groves were to be seen.[4]

In 1794 the armies of General Wayne marched along the Auglaize and Maumee Rivers on an expedition which culminated in the defeat of the Indians at the battle of Fallen Timber and in the Treaty of Greenville. Prior to Wayne's campaign there was a trading post at the confluence of the Auglaize and Maumee on the present site of Defiance, Ohio. There were several French and English families at the post and some Indian villages nearby. Near the rapids of the Maumee on the left bank of the river there was an English trading post run by Alexander McKee.

When Wayne first viewed the confluence of the Auglaize and Maumee he exclaimed about "the very extensive and highly cultivated fields" which lay along the margins of the rivers and appeared "like one continuous village for a number of miles." Never before had he "beheld such immense fields of corn, in any part of America, from Canada to Florida."[5]

As a result of Wayne's decisive victory a definite line of separation was established within the Northwest Territory between Indian lands and those open to white settlement (Fig. 3). The Treaty of Greenville paved the way for a series of treaties which within a quarter of a century brought about the virtual extinction of Indian claims in northwestern Ohio. Its provisions included unobstructed use of the Maumee and some of its tributaries for travel by whites and also established a series of nearly isolated island-like tracts more or less strategically located in the Indian wilderness of northwestern Ohio. At first these tracts offered little inducement to the pioneer settlers, whose minds were full of tales of Indian treachery and savagery. Two of the tracts, however, the twelve mile square centered at the foot of the rapids of the Maumee and the two mile square at the lower rapids of the Sandusky, proved to be more attractive than the others. Both of these regions began to be settled shortly after 1800. The Maumee site was particularly favored because it lay on a main route between Detroit and the settlements of southern Indiana and Ohio.

Between 1805 and 1808 several important Indian treaties were concluded, which opened vast new areas in northwestern Ohio and Southeastern Michigan to white settlement. The first treaty ceded the remainder of the Connecticut Western Re-

[2] E. Bliss, *Diary of David Zeisberger, A Moravian Missionary Among the Indians of Ohio,* trans. E. Bliss (Cincinnati: R. Clarke and Co., 1885), I, p. 30.

[3] *Ibid.*, p. 45.

[4] *Ibid.*

[5] U. S. Congress, *American State Papers,* Class II, *Indian Affairs,* Vol. I (Washington: Gales and Seaton, 1832), p. 490.

serve and the Firelands, lying west of the Cuyahoga River. The westward thrust of settlement which followed brought the settlers almost to the brink of the Black Swamp itself. In 1807 the Treaty of Detroit took from the Indians a swath of land some forty miles wide north of the Maumee, extending as far as Defiance and northward into the thumb of Michigan.[6] The Treaty of Brownstown in 1808 was destined to have the most pronounced effect on the Black Swamp lands, for it included the important provision which ceded a tract of land for a road 120 feet wide

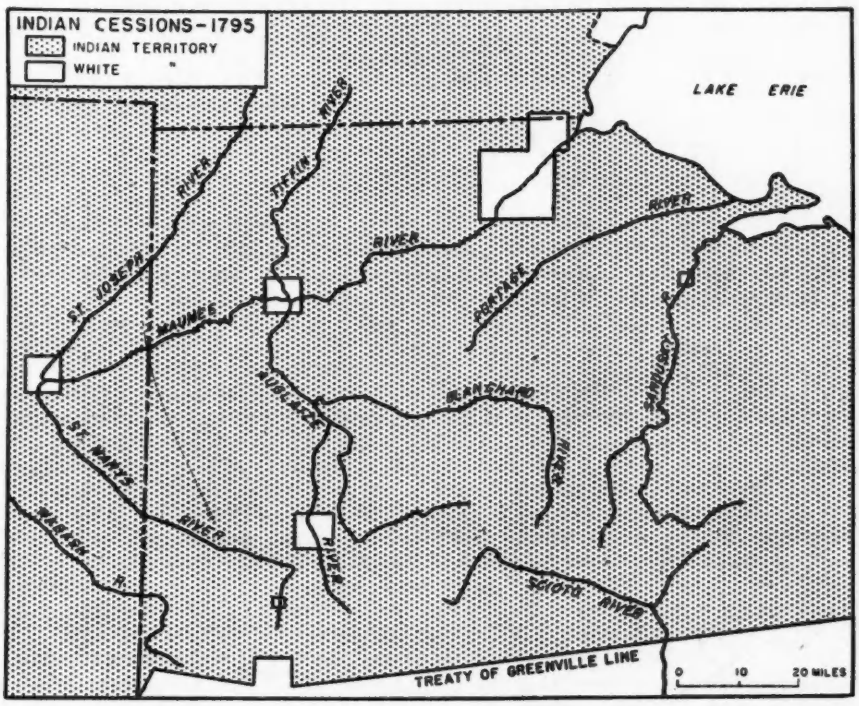

FIG. 3. Distribution of white and Indian territory resulting from the provisions of the Treaty of Greenville, 1795.

from the Maumee Rapids (Perrysburg) east to the western line of the Connecticut Reserve. All the land within one mile of the road on each side was ceded also for the purpose of establishing settlements along the route (Fig. 4).

During the years of treaty making a number of squatters settled near the rapids the Maumee. This early nucleus of settlement in northwestern Ohio is described by Lewis Bond in January, 1809 as "a village of about 100 inhabitants, twenty-

[6] C. Royce, "Indian Land Cessions in the United States," *Eighteenth Annual Report, U. S. Bureau of American Ethnology*, Part II (Washington: Gov't Printing Office, 1899), pp. 676-77.

dwelling houses, and other buildings."[7] On the other hand, during the same period, 1795–1812, the settlement at the lower rapids of the Sandusky (Fremont) progressed more slowly. The Reverend Joseph Badger, a pioneer missionary, wrote an account of the region in 1810.[8] The Wyandots had a "considerable village" on the United States' reserve at the Sandusky rapids which also was the site of a missionary station. The only white inhabitants were the "missionaries, United States' agent, and a few corrupters of heathen morals [i.e. traders]." A school teacher and one "labouring man with his family" were also living at the mission.

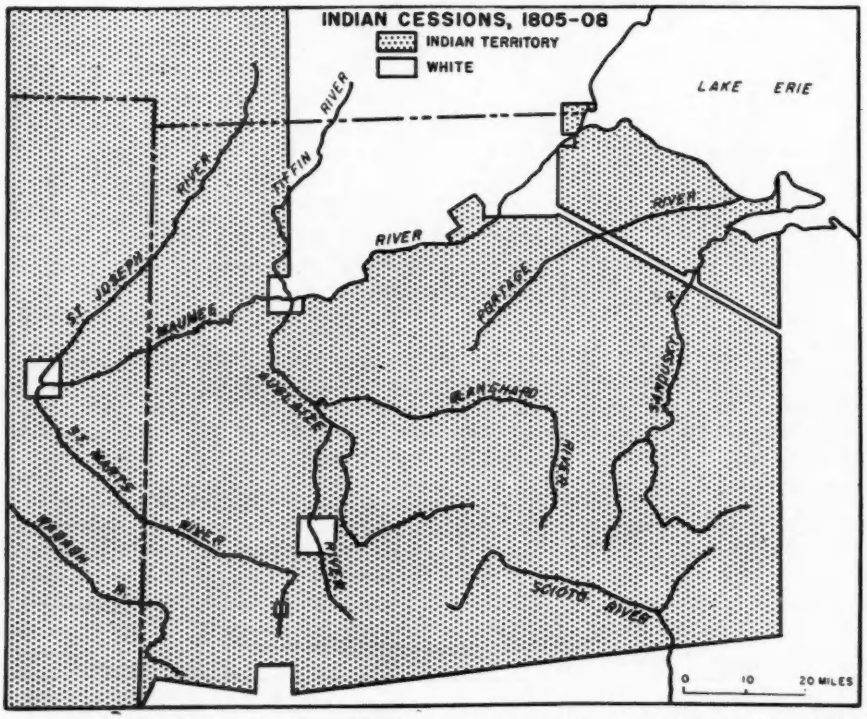

FIG. 4. Distribution of white and Indian territory resulting from the provisions of the treaties signed in the years, 1805–08.

Of the country between the Sandusky and the Maumee, Badger wrote that it was "generally low, interspersed with gentle swells of excellent land well timbered." Streams and some "hideous swamps of two, three and four miles in width" divided these ridges or "swells." There was a "publick road surveyed . . . and cleared out" with bridges over the small streams and ferries on the larger ones between the Cuyahoga River and the western boundary of the Connecticut Reserve. From

[7] F. Cuming, *Sketches of a Tour to the Western Country. . . .* (Pittsburgh: Cramer, Spear, and Eichbaum, 1810), pp. 477–79.

[8] *Ibid*, pp. 437–41.

thence through to the Maumee "there is only an Indian path, through considerable swampy ground."

WAR AND ITS IMPACT ON THE OCCUPANCE

The Maumee Rapids and Lower Sandusky (Fremont) were the only white settlements in northwestern Ohio at the outbreak of the War of 1812. There were no roads, only Indian trails. The total number of whites in this vast area probably did not exceed 400 compared to an Indian population estimated at 3,000. When the news of the fall of Detroit reached the Maumee settlers, there was widespread panic. They abandoned their homes and farms and fled east. They left none too soon, for the Indian allies of the British soon descended on the Maumee settlements and set the torch to everything.

The War of 1812 focused the nation's attention on a region hitherto but little known. For the first time large numbers of Americans were to see for themselves just what the wilderness of northwestern Ohio was like. Campaign strategy called for the control of Lake Erie and the recapture of Detroit, which in turn meant that troops had to be deployed in northwestern Ohio and supply lines maintained. Those who knew that the soldiers had to pass through a wilderness before they could reach Detroit did not know that the wilderness was mostly a "frightful swamp" which defied the passage of packhorse and wagon alike. The soldiers like others before and since, wrote letters home recounting their experiences and complaints in especially descriptive terms. One of these terms was that used to describe the vast morass lying between the Sandusky and Maumee Rivers—the Black Swamp. An entry in the journal of Robert Lucas dated June 10, 1812 contains probably the first recorded reference to the Black Swamp by that name:[9]

> Started from the foot of the Rapids [Maumee] to meet the army proceeded through the wilderness towards Urbana—traveled ab[o]ut 25 miles, a very rainy day and then encamped in what is Called the Black Swamp, had a Disagreeable night of wet and Musketoes.[10]

The first road through the swamp was the trace cut by General Hull's army when they marched to Detroit from Urbana, Ohio. The trace was the width of a wagon track and pushed through some of the worst morasses in northwestern Ohio. Hull's route coincides for the most part with the modern U. S. Highway 68 (Fig. 5). Once established, Hull's trace was used sporadically throughout the war, but its use always involved hardships as did the other war routes in northwestern Ohio. The stories of travel along Hull's trace abound with such phrases as "a thick and almost trackless forest"; man and horse had to travel mid leg deep in mud"; and "the mud was ancle deep in our tents."[11]

[9] Joseph Badger referred to the Black Swamp as the "Maumee Swamp" and "Big Swamp" in 1805 and 1807, respectively.

[10] J. Parish, "The Robert Lucas Journal," *Iowa Journal of History and Politics,* IV (1906): 362.

[11] See Samuel Brown, *Views of the Campaigns of the Northwestern Army. . . .* (Troy, N. Y.: F. Adancourt, 1814), p. 6; and M. Quaife (ed.), *The Capitulation by an Ohio Volunteer* (Lakeside Classics; Chicago: R. R. Donnelly and Sons Co., 1940), p. 209.

The many eye witness accounts of the War of 1812 in northwestern Ohio not only describe the nature of the country, but also demonstrate how unfavorably it was regarded by the soldier. The Black Swamp was to be avoided at any cost. The letters of William Woodbridge written to his wife as he traveled toward Detroit from Marietta tell of his fears as he anticipated having to cross the Black Swamp.[12] Upon arriving at the Maumee in January, 1815, he wrote: "My greatest terrour, the Black Swamp, is passed. . . . No part of this road seems so very bad as has been represented. . . ."[13]

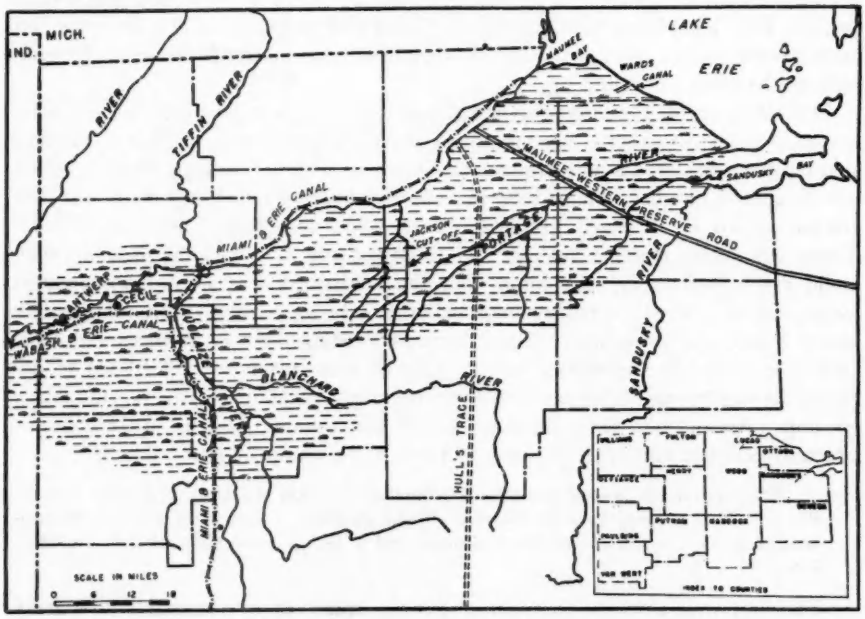

FIG. 5. Location map showing important early improvements in the Black Swamp region —canals, principal roads, iron furnaces at Cecil and Antwerp, and the Jackson Cut-off drainageway.

By contrast, the valleys of the Maumee and Sandusky had received very favorable reports. Lewis Cass exclaimed about the Maumee whose fertile banks were "clothed with deep verdure" and "rich bottoms denuded of timber, as though inviting the labor and enterprise of the settler."[14] Similarly, Elisha Whittlesey wrote his wife from Lower Sandusky: "The place where we are stationed is beautiful.

[12] M. Quaife (ed.) "From Marietta to Detroit in 1815," *Historical Society of Northwestern Ohio, Quarterly Bulletin*, XIV, (1942): 149–50.

[13] The road had frozen over.

[14] W. L. Smith, *The Life and Times of Lewis Cass* (New York: Derby and Jackson, 1856), p. 36.

I have been up the River 13 miles, and for that distance better land than I ever saw elsewhere."[15]

PEACE AND PERMANENT SETTLEMENT

In 1815, the war over, the settlers returned to the areas about the rapids of the Maumee and Sandusky. By 1817 villages had sprung up on both banks of the rivers at each of these rapids sites—Maumee and Perrysburg along the Maumee, and Lower Sandusky and Croghansville on the Sandusky. Again these two regions became the focal points for settlements in northwestern Ohio. There were also about ten settlers living in the abandoned fort at the present site of Defiance.

The unoccupied swamp land between the Maumee and Sandusky was described in Niles' Weekly Register.[16] The low-lying portions of the country, partially covered with water in the winter and spring, "might in most cases be easily drained, which would render them as fertile as they are now rich." The account went on to say that the Black Swamp probably derived its name from the "black, loose, friable loam" which characterizes the soil in this region; and that "the land, in general, of the lake side of this state is not inferior in point of fertility to the Ohio [River] side."

The Indian was rapidly vanishing from the scene. In 1816 their number was "too small to create any alarm whatever. . . ."[17] In 1817 the Indians signed a treaty relinquishing the remainder of their lands in northwestern Ohio with the exception of a few scattered reservations which they were permitted to retain.

THE RETARDATION OF SETTLEMENT

American settlement in northwestern Ohio during the twenty-five years following the Treaty of Greenville (1795) was so meager that it had scarcely modified the face of the land. In 1820, during the first federal census to include northwestern Ohio, the white population of 1,781 had not yet equalled the former Indian population of the region. Here and there log cabins had replaced the wigwam. A sawmill had been built on Swan Creek; there was a grist mill at the Sandusky rapids; and Defiance had three stores, but otherwise all this part of the state was a vast wilderness. Almost without exception the whites were located on the sites of former Indian villages and had not yet dared to settle within the borders of the Black Swamp itself. Even the circulation pattern remained the same as it had during the Indian occupance of the region. The only new route was Hull's trace, but it was little used. The single sweeping change which had occurred was the removal of the Indian rights to the land, except for scattered reservations. However the landscape showed little evidence of this change. Although faint, the impress on the land left by the Indians, traders, soldiers, and early settlers in the

[15] E. Benton, "Northwestern Ohio During the War of 1812," *Western Reserve Historical Society Tract* No. 92 (1913): 93–94.

[16] January 11, 1817: 323.

[17] *Ibid.*, p. 324.

decades preceding 1820, together with the ideas people formed concerning the land, provides the foundation on which the settlement of the Black Swamp rests.

In 1820 the federal land surveys, begun in northwestern Ohio in 1819, were well on their way towards completion, and the region was divided into counties. Just before the counties were laid out, one of the original surveyors advised the governor of Ohio as follows:

> The lands on all the principal streams west of the Sandusky are generally of first quality for a short distance on either side; but on leaving the streams, a few miles, you fall into very wet lands . . . great care should be taken so as to have some principal stream pass as near the center of each county as possible, as the population for a number of years, will not leave the water courses to any considerable distance.[18]

Judging from Bourne and Kilbourne's map of Ohio in 1820, it would appear as if the surveyor's advice had been followed in part. His prediction concerning the pattern of settlement was sound, for three or four decades passed before the interfluve regions were occupied to any extent.

Why had northwestern Ohio been so slow to develop when during the same twenty-five year period the neighboring Western Reserve was rapidly being settled? There is no simple answer. The retardation of northwestern Ohio may be chiefly ascribed to the slow removal of the Indians and the War of 1812 more than to the "fearsome" Black Swamp.[19] It is also important to note that northwestern Ohio was the last major portion of the state to be surveyed and offered for sale by the government, and that it was not actively promoted by a land company as was the neighboring Western Reserve. The depression which followed the War of 1812 and culminated in the Panic of 1819 must also be considered in evaluating the speed of settlement, for the depression occurred at a time when northwestern Ohio had just been freed from the dangers of war and Indians. As a result of the Panic the number of acres of public land sold in 1820 was less than a quarter of the total in 1813.[20] However land sales increased in the mid 'twenties as did immigration and then the Black Swamp itself became the only major obstacle to settlement.

THE CIRCULATION PATTERN BROADENS

The soldiers who fought in northwestern Ohio during the War of 1812; the up-and-coming statesmen of the new northwest; and particularly the settlers of northwestern Ohio and southeastern Michigan, were all quick to recognize the necessity of a good road across the Black Swamp. Pressure for the construction of such a road was mounting steadily in both Ohio and Michigan, particularly in the latter. Michigan was sensitive to her relative isolation from the East and had

[18] Letter from Alexander Holmes to Gov. Ethan A. Brown, Feb. 7, 1820 in J. Kilbourn, *Public Documents Concerning the Ohio Canals . . . to the Close of the Legislature of 1831–32* (Columbus: J. N. Whiting, 1832), p. 12.

[19] J. Badger, *A Memoir of Reverend Joseph Badger, Containing an Autobiography* (Hudson, Ohio: Sawyer, Ingersoll and Co., 1851), p. 126.

[20] T. Greer, "Economic and Social Effects of the Depression of 1819 in the Old Northwest," *Indiana Magazine of History,* XLIV (1948): 232.

fresh memories of the fall of Detroit during the War of 1812. She also felt that a road across the swamp would result in an increase in settlers sufficient to make Michigan Territory a state.

In 1815 there was still no road from the Sandusky to the Maumee rapids. The mail carrier followed a blazed Indian trail, probably the very same path described by Badger five years before. In the fall of 1818 when Tilly Buttrick crossed the Black Swamp on his way to Lower Sandusky he "had no road; the only guide for the traveler [being] marked trees," and even then Buttrick got lost.[21] The provisions of the Treaty of Brownstown in 1808 providing for a road through the Black Swamp had not yet been acted upon.

In 1817 Governor Lewis Cass of Michigan and General Duncan McArthur wrote a joint letter advocating the construction of a road between Detroit and Lower Sandusky.[22] They argued that the Black Swamp rendered "the Territory of Michigan an insulated [sic] point upon the map of the nation." The approach by water was "uncertain, temporary, and . . . inconvenient" because Lake Erie was closed by ice for a considerable portion of the year, and it was at that season, except for a short period in mid-winter that land communications were most difficult. Their plea included consideration of the military and political benefits to the nation as well as the monetary gains which would result from the "sale and settlement of this land" which "will be aided and encouraged by making roads where the population of the country will long be unable to make them." These words went unheeded as far as northwestern Ohio was concerned; however a road was completed from Detroit to the Maumee rapids in 1818.

Estwick Evans, in his *Pedestrious Tour of Four Thousand Miles During the Winter and Spring of 1818,* gives a vivid account of the difficulties and terrors he encountered while traveling through the "celebrated Black Swamp" early in March 1818. He found the swamp in its very worst state; there was an unusual quantity of snow and ice on the ground, the latter not being sufficient to bear Evans' weight. "The freshets were great, the banks of the creeks overflown, and the whole country inundated."[23]

In 1822 a bill lay before Congress for a road from the Maumee rapids to the Western Reserve. The report accompanying the bill describes the Black Swamp as an "extensive morass" winding "around the southeastern border of Michigan" and "extending so far southwesterly as to interrupt all communication by land between the settlements in Michigan and those of the interior of the United States."[24]

[21] Tilly Buttrick, *Voyages, Travels, and Discoveries of Tilly Buttrick, Jr.,* Vol. III of *Early Western Travels, 1748–1846,* R. G. Thwaites, ed. (32 vols.; Cleveland: A. H. Clark Co., 1904–07), p. 84.

[22] U. S. Congress, *American State Papers,* Class X, *Miscellaneous,* Vol. II (Washington: Gales and Seaton, 1832), p. 596.

[23] *Early Western Travels, 1748–1846,* III. p. 201.

[24] U. S. Congress, House, Committee on Roads and Canals, *Report . . . Relative to Carrying into Effect the Treaty of Brownstown. . . ,* Rep't 50, 17th Cong., 2d. Sess. (Washington, 1822), p. 4.

It was also observed that the Black Swamp could be "made subservient to all the purposes of profitable agriculture" by artificial drainage, and that "the construction of any road must *precede* the establishment there of any considerable population."[25]

The construction of the Maumee and Western Reserve Road was finally approved by Congress in 1823. Building the road was a prodigious task. It passed through the heart of the swamp, and numerous streams had to be bridged. When it was completed in 1827, the Black Swamp road "was simply a strip one hundred and twenty feet wide cleared through the woods, with a ridge of loose earth about forty feet in width between the ditches along the sides."[26] The trees on either side were about 100 feet high, and their leaves nearly shut out the sun's rays except during the period of high sun. For a few years it was "a tolerable road"—during the dry seasons. Shortly after the road's completion a line of four horse post coaches was established, but the attempt to run the stages regularly was a failure. ". . . the more the road was traveled the worse it became." The Black Swamp road soon acquired a national reputation "for being, perhaps the worst road on the continent."[27] But, because it was the only road through the Black Swamp, it continued to be used by the ever increasing waves of settlers. "Hauling stalled teams out of the worst mudholes had become a regular and well established employment of the settlers along the route, and in 1834, 1835, and 1836, there were thirty-one taverns between [Fremont] and Perrysburg, an average of a tavern for every mile of road."[28]

The building of the road across the Black Swamp in the 1820's was contemporaneous with two other developments in the circulation pattern. One of these was the mounting use of Lake Erie as an east-west highway. The second, and closely associated development, was the successful completion of the Erie Canal which inaugurated a canal building era in Ohio that lasted some twenty years. These two developments resulted in the diversion of a large proportion of the westward traffic from the miserable Black Swamp route.

Ground was broken for the Wabash and Erie Canal in 1832 and for its important connecting link, the Miami and Erie Canal, in 1833 (Fig. 5). These two canals directly affected northwestern Ohio, for they furnished the Wabash and Maumee valleys a continuous water route to Lake Erie and provided a through water connection from Cincinnati to Toledo.

New post routes were being established. In 1822 Hull's trace became a part of the post route from Bellefontaine to Perrysburg via Kenton and Findlay. Mail was carried between Detroit and the East by way of Perrysburg, Fremont, and Cleveland once a week in 1823, thrice a week in 1827, and daily in 1834.[29]

[25] *Ibid.*, p. 5.

[26] H. Everett, *History of Sandusky County* (Cleveland: H. Z. Williams and Bros., 1882), p. 145.

[27] *Ibid.*

[28] *Ibid.*

[29] C. E. Carter (ed.), *The Territory of Michigan, 1820–1829*, Vol. IX of *The Territorial*

The development of Lake Erie as a route was in the beginning more favorable to the settlement of southeastern Michigan than it was to northwestern Ohio. The lake provided a convenient means for by-passing the Black Swamp. In June, 1822, the *Detroit Gazette* chortled: "So numerous have been the arrival of emigrants since the opening of navigation, that it is difficult at this time to ascertain, their actual numbers. . . ."[30] The greatest number of emigrants were from New York. In 1826 one thousand people landed at Detroit during the first two weeks following the opening of lake navigation.[31]

The Black Swamp also served to divert through Canada many emigrants going from Buffalo to Detroit. In February, 1823 families were arriving "from the east, through Canada in sleighs. . . ."[32] By 1828 those persons dreading a trip across

TABLE I

A COMPARISON OF THE POPULATION OF THE SIX SOUTHEASTERNMOST COUNTIES OF MICHIGAN AND THE NINE NORTHWESTERNMOST COUNTIES OF OHIO, 1830–1890[a]

Year	Population[b]	
	Michigan	Ohio
1830	14,585	2,955
1840	95,853	38,916
1850	120,721	73,457
1860	146,490	129,819
1870	191,860	189,317
1880	248,673	193,678
1890	314,740	291,375

[a] Hillsdale, Jackson, Lenawee, Monroe, Washtenaw, and Wayne in Michigan (3,945 sq. miles); Defiance, Fulton, Hancock, Henry, Lucas, Paulding, Putnam, Williams, and Wood in Ohio (4,049 sq. miles).

[b] Michigan statistics *exclude* all cities over 1,000 except in 1880 and 1890 when only Detroit is excluded. Ohio statistics are for the *total* population except in 1880 and 1890 when Toledo is excluded.

Lake Erie "either on account of seasickness or gales of wind [could] be accommodated with a safe, cheap, and comfortable conveyance through a wholesome and interesting portion of the country."[33] The conveyance referred to was a new line of tri-weekly stages between Buffalo and Detroit through Canada. The irregularly operated stages across the "not-so-wholesome" Black Swamp were poor competition for the Canadian line.

The Black Swamp, however, was actually a factor that was favorable rather than

Papers of the United States (Washington: Gov't Printing Office, 1943), pp. 367, 1087; R. C. Buley, *The Old Northwest, Pioneer Period, 1815–1840* (Indianapolis: Indiana Historical Society, 1950), I, p. 465.

[30] *Detroit Gazette*, June 7, 1822.

[31] *Ibid.*, May 23, 1826.

[32] *Ibid.*, February 28, 1823.

[33] *Ibid.*, August 28, 1828.

unfavorable to the settlement of southeastern Michigan. Had there been no swamp, it is reasonable to assume that southeastern Michigan would have been settled only after most of the land in northwestern Ohio had been taken up. A comparison of the population of southeastern Michigan and northwestern Ohio shows that the population of the former has exceeded that of the latter throughout the period of this study (See Table I).

THE LAND AS SEEN BY THE PIONEER

Between 1820 and 1830 there was but little progress made in the settlement of northwestern Ohio (Fig. 6). The Maumee valley showed a gain in population, and the land between the Sandusky River and the Western Reserve was filling up. The range of townships immediately west of the Sandusky had begun to be settled, particularly in Seneca County, which lay almost entirely outside of the Black Swamp. Here and there at the confluence of major streams and near the remaining Indian reservations, there were signs of increasing population. The Black Swamp itself was almost entirely uninhabited except for a few hardy families who dared to establish themselves along a river bank or on a sand ridge within the fearful morass.

What sort of land did the pioneer who crossed or settled within the borders of the Black Swamp see?

There were only two important routes across the Black Swamp for the early settlers, and it was from the scenery along these routes that they received their first impressions of the land.[34] One route, the Black Swamp road, crossed the swamp from southeast to northwest between Fremont and Perrysburg; while the other, Hull's trace, crossed it from south to north. The former crossed the greater extent of swamp, but there was sufficient difference between the country traversed by each road for the accounts left by travelers on them to furnish us with a description of the bulk of the Black Swamp country.

In the plan of the road from Perrysburg to the Western Reserve, drawn up in 1823, the land is described as low and wet; and ash, elm, oak, maple, linden, hickory, and cottonwood are the most frequently mentioned trees.[35] The timber was heavy and no prairies were to be seen in the thirty miles between Fremont and Perrysburg. There were twenty-two streams of varying magnitude to be crossed in this stretch. Here and there was a limestone outcrop. Stretches of mud "from knee to belly deep to our horses for 8 or 10 miles together" were reported late in the spring. "The land . . . is nearly level," wrote Lewis Cass,

[34] James Riley, one of the original surveyors of northwestern Ohio, suggested in 1819 that the emigrant's best approach to northwestern Ohio and northeastern Indiana was by way of Lake Erie to the Maumee, up that river or its tributaries, thence overland to their destination. *History of Van Wert and Mercer Counties, Ohio* (Wapakonetta, Ohio: R. Sutton and Co., 1882), p. 292.

[35] Quintas Atkins, "Plan of the Road Leading from the Foot of the Rapids of the Miami of Lake Erie to the Western Boundary of the Connecticut Western Reserve," Western Reserve Historical Society, *Atkins Papers,* MSS 2018.

> the streams . . . are in many places interrupted with fallen timbers and other obstructions which cause the water to spread extensively. In all the wet seasons of the year the surface is inundated for many miles. The passage of a wheel carriage is physically impracticable and for hours in succession the water will reach the saddle skirts of a horseman. As the season advances, and the rains cease, the waters gradually subside, but the mud becomes deeper and heavier. The labor of traveling is almost intolerable to the horse and rider.[36]

Although most observers only saw the swamp soil as a "mud," William Woodbridge described the swamp as "consisting of a basin of hard clay, upon which is bedded in thick stratum of the most fertile black loam."[37] An 1838 geological report gives a more detailed soil profile of the Black Swamp in northern Wood County. The uppermost layer is described as the "dark surface soil," beneath this is a "yellowish clayey stratum sometimes containing pebbles" beneath which is a "bluish clayey stratum," in which pebbles are sometimes found. "Where pebbles predominate it assumes the character of a blue compact hardpan." The soil rests on limestone.[38]

Those who passed through the Black Swamp from the south along the route of Hull's trace received a somewhat different impression. There were fewer streams to be crossed, but the same condition of obstructed channels prevailed, resulting in inundation of large tracts.

The outstanding feature along Hull's trace was the presence of occasional treeless or almost treeless areas. Most of these were known as wet prairies. "The water was from one to three feet deep, the grass from three to eight feet high."[39] Observers noted the "luxuriant growth of grass and herbs, and an endless variety of beautiful native flowers . . . interspersed with a few small islets, or groves of oak and hickory timber . . . here and there a solitary oak tree or two standing out in the open expanse. . . ."[40]

There were also several sandy ridges crossed by Hull's trace. These ridges were observed by John Riddell in 1836 who noted the "close resemblance of this sand to that every day thrown up by Lake Erie on its present shores."[41] The general correspondence in altitude between the sand banks in different places led to the inference that the surface of the lake "formerly stood some forty or fifty feet above its present level. . . ." Riddell also remarks that a Judge Lane "supposes from his own observations . . . that the Lake has left traces of two or three successive periods

[36] *Detroit Gazette,* February 28, 1826.

[37] C. E. Carter (ed.), *The Territory of Michigan, 1805–1820,* Vol. X of *The Territorial Papers of the United States* (Washington: Gov't Printing Office, 1942), pp. 819–20.

[38] *Second Annual Report on the Geological Survey of the State of Ohio* (Columbus: S. Medary, 1838), p. 110.

[39] [M. A. Leeson and C. W. Evers], *Commemorative Historical and Biographical Record of Wood County, Ohio* (Chicago: J. H. Beers and Co., 1897), p. 36.

[40] S. Williams, "Two Western Campaigns in the War of 1812–13," *Ohio Valley Historical Series,* No. 7, *Miscellanies,* Part 2 (Cincinnati: R. Clarke and Co., 1871): 21–22.

[41] *Report of John L. Riddell . . . Appointed . . . to Report on the Method of Obtaining a Complete Geological Survey of this State,* Ohio [Executive Documents], 1836/37, Rep't No. 60 (Columbus: James B. Gardiner, 1836), pp. 19–20.

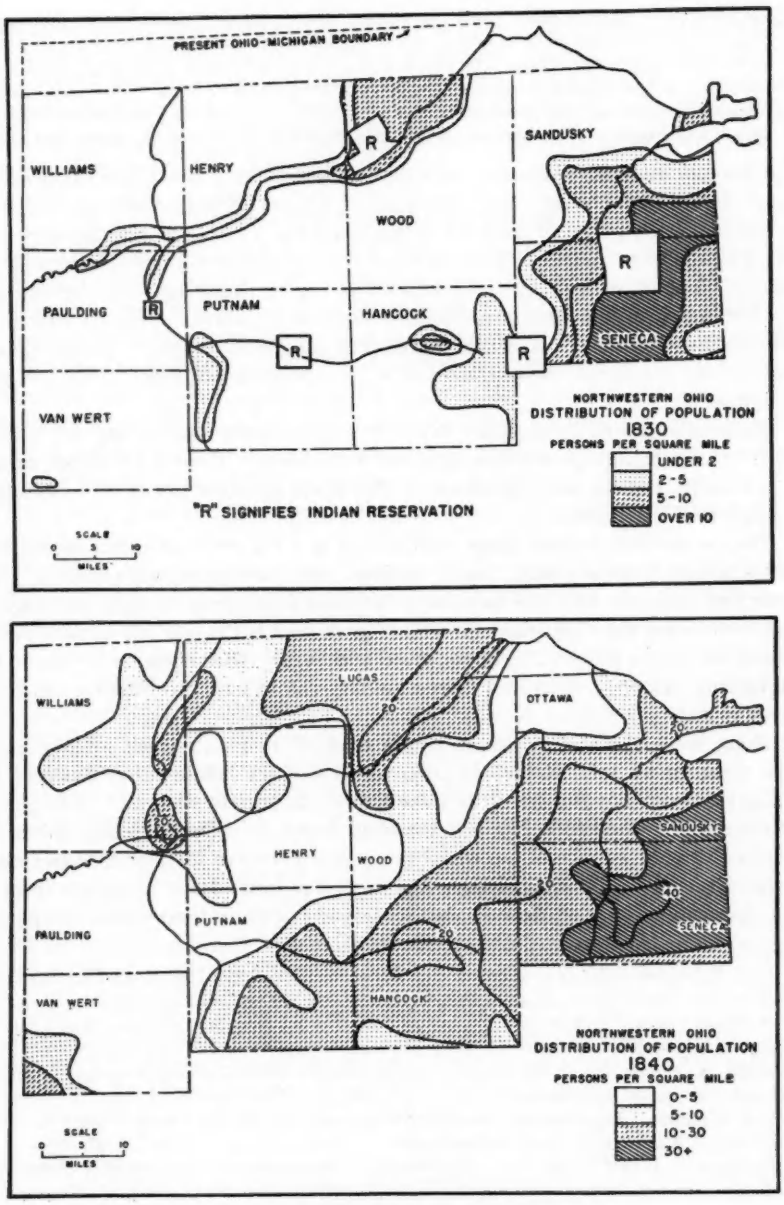

FIG. 6. Distribution of population in 1830 and 1840.

of subsidence" and "that there are two or three systems of lacustrine sand ridges, differing merely in elevation."[42]

Aside from the treeless areas found in association with the sand ridges, the swamp forest prevailed and was identical to that growing along the east-west road. Now and then swaths of fallen timber amid a confusion of underbrush lay along the road—the scars of tornadoes which had ripped through northwestern Ohio.[43] The average slope of the land throughout was only about four feet per mile and locally even less. The Black Swamp was truly a wilderness greater in extent and degree than any previously experienced by most of the emigrants from the more settled East.

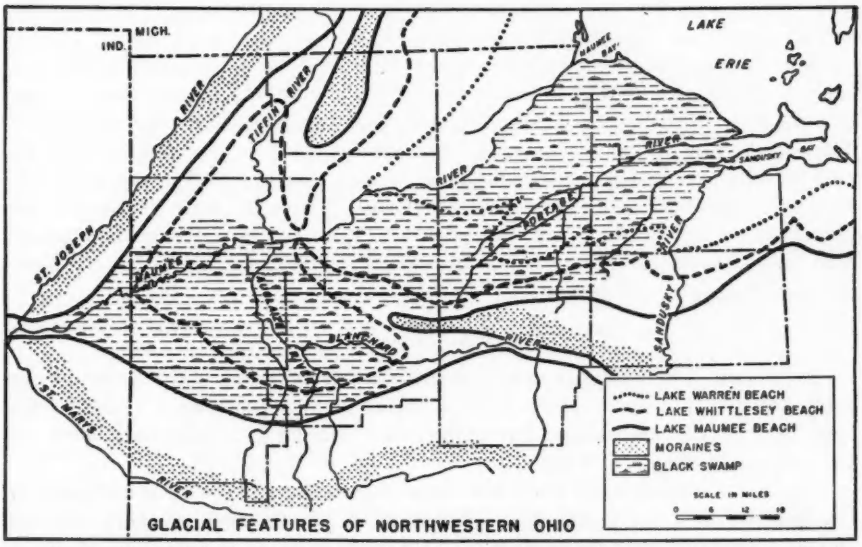

FIG. 7. Glacial lake beaches and moraines of northwestern Ohio (after F. Leverett, *Glacial Formations and Drainage Features of the Erie and Ohio Basins,* U. S. Geol. Survey Monograph XLI, Plate XI).

The Black Swamp was a product of the final spasms of glaciation. With the retreat of the ice front moraines were deposited, and the ancestors of the present Great Lakes were born in newly scoured basins. The work of erosion has not yet erased the moraines and beach lines left by the glacier and glacial lakes. Less than one hundred years ago the Black Swamp still marked the most level portion of the lacustrine plain formed by the retreating lakes. The limits of the Black Swamp were set primarily by the beaches of Lakes Maumee and Whittlesey together with the peculiar drainage pattern which followed the melting of the glacier (Fig. 7).

[42] *Ibid.*

[43] On June 9, 1953 a tornado struck northwestern Ohio south of Bowling Green and directly across the path of Hull's trace.

Sand bars, spits, and even small rocky islands (formed in part by limestone outcrops), together with the sandy beaches, remained after the water's subsidence to lend some variety to the otherwise almost featureless lake plain. The sandy products of wave action, which seldom contribute more than ten feet to the relief of the plain, may be considered prominent only because the region as a whole is so flat.

Plant life, however, was sensitive to these small aberrations as well as to their sandy soils. Oak and hickory was the common vegetation of the sandy ridges and in close association with the sandy ridges were the wet prairies. The dominant plant cover was the dense swamp forest type vegetation composed of a great variety of trees. The trees grew tall and straight with small crowns because of their closeness to each other. It was a splendid virgin growth known today as the deciduous swamp formation. There were no conifers (Fig. 11).

The swamp forest with its great variety of species contrasts sharply with the beech-maple or oak-hickory forest associations. The variety comes from the fact that the trees in the swamp are sensitive to small variations in surface drainage.[44] The degrees of drainage are reflected by changes in species. In some cases small rises in surface elevation result in the presence of trees common to areas which are as a whole much drier than the swamp. Sampson uses the term "swamp forest formation" to include the entire successional series of swamp forest communities.[45] The original vegetation of the Black Swamp admirably demonstrated the complexity of the swamp forest formation.[46]

SPECULATION AND DISEASE

By the mid 1830's the tempo of immigration had increased, and the about-to-be completed canals in northwestern Ohio attracted many speculators. The lack of a local labor supply necessitated the introduction of a large number of laborers to work on the canals.

The canal workers lived in crowded and filthy tents. There were epidemics of smallpox, typhoid, and pneumonia. At certain seasons the ague was very common and in some years cholera broke out. Such conditions, of course, often made it difficult to get or keep construction gangs; thus delaying the completion of the canals.

Again northwestern Ohio had left a bad impression on a large number of potential settlers, and the reputation for unhealthiness which the region acquired was not easily erased. As if all this were not enough, another depression struck the nation in 1837 and was especially severe in the "western country."

[44] "In many swamp forest habitats an abrupt elevation of seven to ten inches gives sufficient local drainage for beech-maple or oak-hickory. On the other hand a slope of three to four feet per mile may lead to an elevation of several feet above the lowest depression yet not be sufficiently drained for beech-maple." H. Sampson, "Succession in the Swamp Forest Formation in Northern Ohio," *Ohio Journal of Science*, XXX (1930): 348.

[45] *Ibid.*, pp. 342–48.

[46] The original vegetation of Ohio has been worked out by P. Sears, and H. Sampson and E. Transeau. The work of Sampson and R. E. Shanks is particularly concerned with the swamp forest.

There had been widespread speculation throughout the "West" in 1835 and 1836, and the Maumee valley was one of its centers. The whole northwest "was regarded as a sort of lottery-office" to which anyone "might resort for the accumulation of wealth. . . ."[47] The financial panic of 1837 caused business to stagnate and money became scarce. However, in the late 1830's northwestern Ohio was better insulated against the ill effects of depression and unfavorable reports than she had been twenty years before, for, panic or no, the commercial advantages of the Maumee valley could not be ignored.

The nearly completed Wabash and Erie, and Miami Canals together with the improved Black Swamp road were factors which encouraged settlement and more than counter-balanced the deterrent forces (Fig. 5). Settlement continued to advance during the depression of 1837, although at a somewhat slower pace. The population of the Black Swamp, however, remained far behind that of the rest of the region.

In 1840 the two easternmost counties, Seneca and Sandusky, were the most populous in northwestern Ohio with 18,128 and 10,182 people respectively. Hancock County, adjoining Seneca on the west, with 9,986 was not far behind. Almost all of Hancock County lay south of the edge of the Black Swamp. Northwestern Ohio began to fill up from east to west, and the fact that Hancock County contained nearly twice as many people as Wood County, which lay directly north within the Black Swamp, indicates the extent to which the Black Swamp caused settlement to detour around it. The population density map for 1840 shows this clearly (Fig. 6). The same map also indicates the orientation of settlement along the axes of the Black Swamp road, Hull's trace, the northern portion of the Maumee valley and the Tiffin River.

CANALS AND THE PROGRESS OF SETTLEMENT

The two canals under construction in northwestern Ohio were heralded as the cure to the region's isolation and backwardness. Similar claims were being made for the railroads that were being proposed in that part of the state. In 1839, before either the canals or the railroads were completed, a Wood County farmer, bitterly complaining of the lack of wagon roads, said that people had their heads too stuffed with canals, railroads, and the like to find room for minor improvements such as roads.[48] The farmer's complaints were not entirely unjust, especially regarding the canals. While the canals did aid the progress of northwestern Ohio as a whole, they were relatively ineffective in improving the status of the Black Swamp proper.

One would naturally expect that in a region so sparsely populated as northwestern Ohio there would soon appear a concentration of population along the routes of the canals (Fig. 5). However, such a pattern of population failed for the most part to materialize until well after the completion of the canals. Con-

[47] J. Lanman, "The Progress of the Northwest," *Merchants' Magazine and Commercial Review,* III (1840) : 39–40.

[48] H. Perkins (ed.), "Northern Ohio Scene, 1839," *Historical Society of Northwestern Ohio Quarterly Bulletin,* XV (1943) : 211.

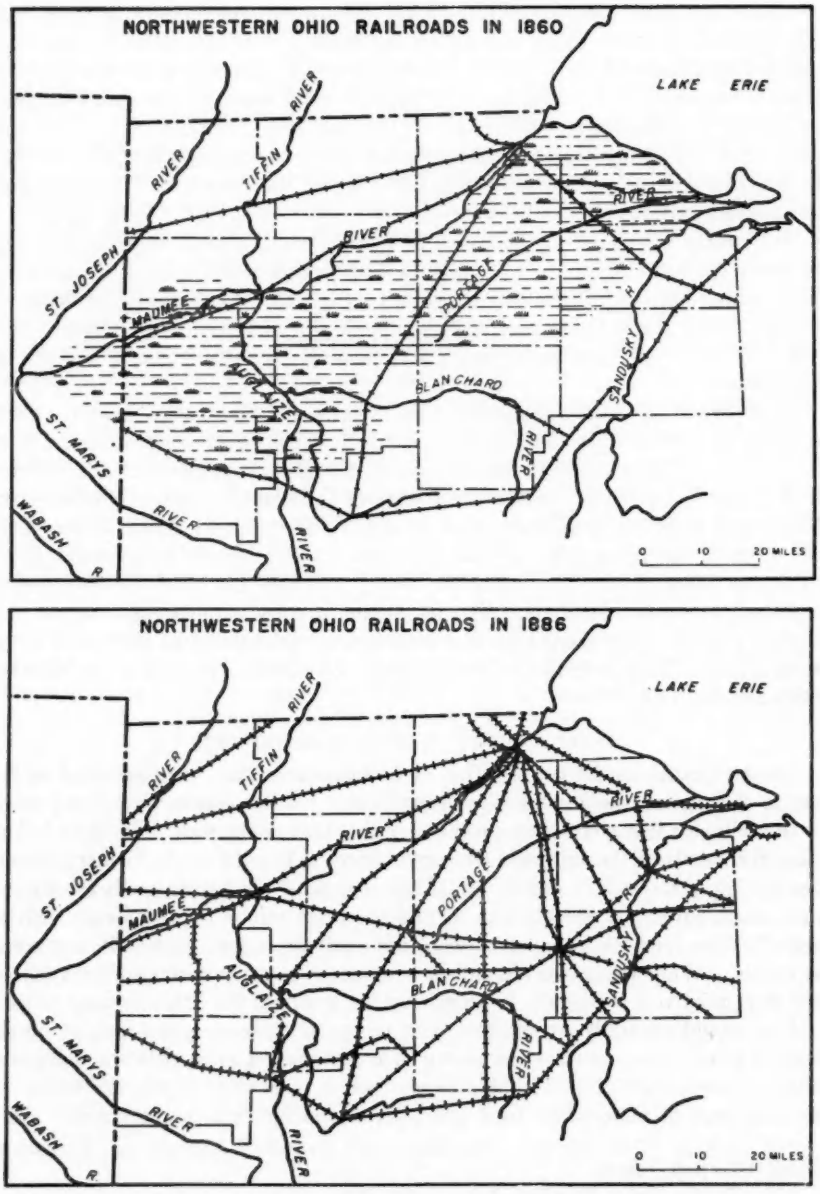

FIG. 8. Railroads in northwestern Ohio in 1860 and 1886.

gress had granted to the state of Ohio tracts of land five miles wide in alternate sections along the proposed canal routes. These lands were to be sold by the state to help defray the costs of canal construction, but canal lands were withheld from public sale until after the completion of the canals in 1843 and 1845. In 1850 the Ohio legislature was investigating complaints that the exorbitant price of $2.50 per acre for canal lands had "to a great extent prevented settlement and improvement of a large and fertile portion" of northwestern Ohio "by diverting . . . new settlers to such states and territories where the same kind of lands" were sold at $1.25 an acre.[49] There was further complaint of the disposal of large tracts to people who

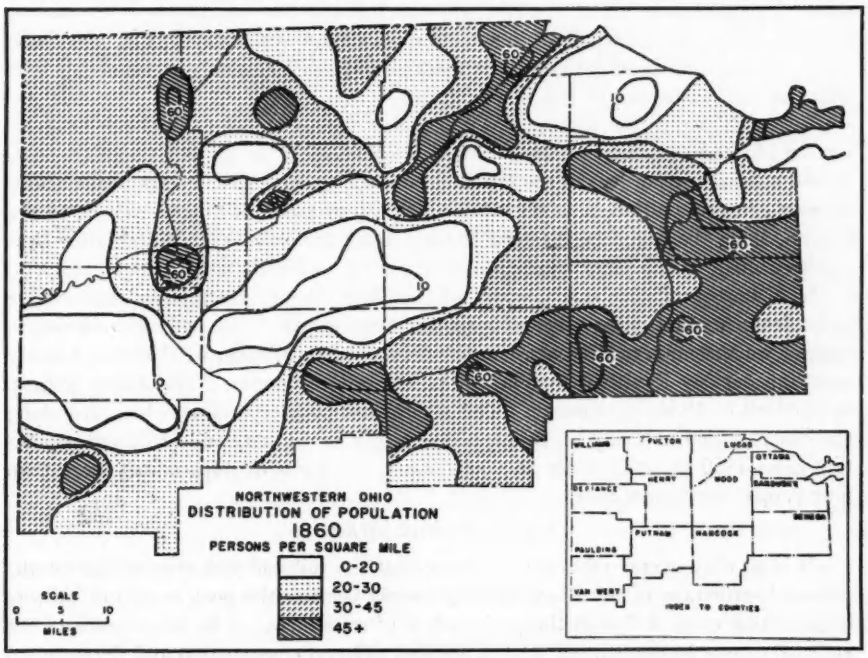

FIG. 9. Distribution of population in 1860.

do not enter and improve the land.[50] These facts account best for the relatively low population density along the canals prior to 1860.

The canals have been credited with the opening up of the tributary agricultural area in the brief period between their completion and the coming of the railroads.[51]

[49] *Special Report of the Auditor of State Relative to Land Agency of J. W. Allen. . . .* Rep't. No. 32, Ohio [Executive Documents], Vol. 16, pt. I (1852), (Columbus: S. Medary, 1852), p. 581.

[50] *Ibid.*

[51] L. Newcomer, "Construction of the Wabash and Erie Canal," *Ohio State Archaeological and Historical Quarterly,* XLVI (1937): 199.

Bogart states: "Before the completion of the [Miami] canal in 1845 not a single bushel of grain or a single barrel of flour was exported from [northwestern Ohio]."[52] The canals stimulated the business in forest as well as in farm products. Lumber, staves, hoop-poles, ashes, etc., which previously had been of little value locally, now were a source of income to the settler. Undeniably the canals furnished an outlet for many farm products and surpluses hitherto unmarketable. The fact that nearly all the canal traffic was local, rather than through, further demonstrates the canals' contributions to the farmers. Canal tonnage reached a peak in the early 1850's after which it steadily declined despite the continual lowering of tolls. The railroads, some of which were built parallel to the routes of the canals, brought about the downfall of the system of inland waterways (Fig. 8). The canals during their brief period of ascendancy (1843–57) had only a relatively slight effect on the settlement of the Black Swamp.

Although population increased considerably throughout northwestern Ohio in the decade 1850–60, the greatest numerical increase in density of population occurred outside the borders of the Black Swamp (Fig. 9). Exceptions to the above appeared in areas adjacent to the canals where they passed through or near to the swamp, along the Maumee-Western Reserve road, and Hull's trace, the latter having been made into a plank road from Perrysburg to Findlay.

It is worthy of note that no part of Paulding County lay further than twelve miles from a canal. No other county in northwestern Ohio had such access to canals; yet the numerical increase in the density of population in Paulding County was considerably less than that in any of the other counties. The Black Swamp covered all of Paulding County. The six townships in Paulding which lay along the canals added as many as twenty-three people per square mile to their population from 1850 to 1860, while none of the six interior townships added more than four people per square mile.

DRAINING THE SWAMP

It is an easy oversimplification to state that the railroad was responsible for the eventual settlement of the Black Swamp merely because the peak period of railway construction coincided with the peak period of settlement. The importance of the railroad cannot be denied, but were it not that railroad construction and the development of systematic drainage coincided, the rate of settlement would have been much slower.

The settler in northwestern Ohio was concerned first with obtaining that land which had the best natural drainage. The availability of transportation was ordinarily a secondary consideration. An examination of land values (*ca.* 1869) makes the importance of natural drainage clear. In every county throughout the Black Swamp the townships crossed by beach ridges were estimated at greater value than the land in adjoining townships which were not traversed by ridges.[53] In Defiance

[52] E. Bogart, *Internal Improvements and State Debt in Ohio* (New York: Longmans, Green, and Co., 1924), p. 86.

[53] *Thirty-first Annual Report of the Ohio State Board of Agriculture for the Year 1876* (Columbus: Nevins and Myers, 1877), p. 494.

County, for example, the six townships crossed by beach ridges had an average valuation of $13.18 per acre. On the other hand, the six remaining townships, some having the benefit of the Maumee and Auglaize Rivers, the Miami Canal, railroads, and one the county seat, had an average valuation of only $8.88 per acre.[54] The higher value of the ridge townships lay in their superior drainage and not in any market advantages.

Drainage is the key to the settlement of the Black Swamp. As early as 1816 the swamp was recognized as being potentially productive if properly drained. In 1853 the *Perrysburg Journal* was predicting that:

> . . . the wet and overflowed lands of Wood County will be drained and eventually become the garden spot of Ohio. It will take time . . . the tide of emigration will no longer pass by them to go further and fare worse.[55]

From the War of 1812 until past the mid-century mark, most settlers preferred to travel a little further, and why not, when throughout the Old Northwest land was generally "too abundant and cheap" to justify choosing a farm which required ditching in addition to the usual pioneer labors.

The progress of Black Swamp drainage is a rough index to the progress of settlement. Every advance made in the technique of drainage helped demonstrate to the prospective settler the habitability of the region. The improvement of the Maumee-Western Reserve road in 1839 first brought public attention to the fact that the Black Swamp was capable of drainage, despite its gentle gradient which in many places was less than four feet per mile. Deep side ditches and frequent culverts were prominent features of the newly macadamized road. The road ditches led to natural and artificial channels which eventually drained into Lake Erie. The result was that the lands along the ditches were relieved of their excess water. Open ditches were, of course, an integral part of any road through the Black Swamp, but roads were few and far between, and none carried the volume of traffic of the Maumee-Western Reserve road.[56]

The farmer's early drainage practices consisted of plowing his fields into narrow bands separated by dead furrows to catch the excess water. Ideally, he would also have a ditch leading away from his field, but often this meant emptying water on a neighbor's farm. "Neighbors could not always agree, in fact in a mixed settlement of Germans, English, and Yankees they seldom would agree or sacrifice a jot or tittle of their own for another."[57] Increased awareness of the necessity of systematic drainage brought about the passage of a law in 1859 which provided for a system of public ditches. The early "ditch laws" were often inadequate and were blamed by some for retarding settlement in northwestern Ohio. In many cases, for instance,

[54] *Ibid.*

[55] *Perrysburg Journal,* December 19, 1853.

[56] During the winter months of 1837–38 some 5,500 travelers passed over the road, averaging 180 footmen, and 86 sleighs and wagons a day. [Leeson], *op. cit.,* pp. 182–83.

[57] Everett, *op cit.,* p. 205.

only one year after settlement, taxes levied for ditches often amounted to the original price paid for the land.[58]

It soon became apparent that open ditches and furrows were not in themselves adequate for successful drainage of the swamp. Underdrains were also needed, but there were no nearby tile factories, and when such factories first appeared on the scene their product was too expensive for most farmers. The farmer improvised by laying saplings or stones in a trench and covering them. Wooden underdrains were a later improvement which came into wide use. These were constructed by

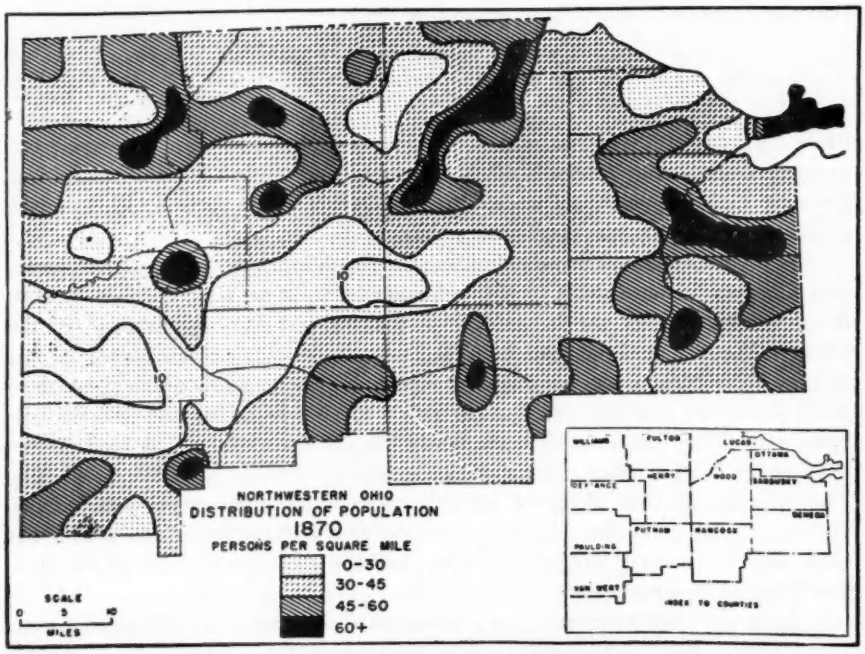

FIG. 10. Distribution of population in 1870.

nailing two boards together into a "V" which was then inverted and placed into the trench. The first clay tile were hand made and horseshoe-shaped, having no bottom.

The increasing demand for cheap clay tile led to the building of tile factories throughout northwestern Ohio. It was soon discovered that there was abundant clay beneath the Black Swamp suitable for tile manufacture, and such clay was seldom more than a foot or two beneath the surface. In 1870 there were only five tile factories in the Black Swamp counties. Nine years later there were eleven in Putnam County alone, manufacturing 80,000 feet of tile during the season.[59]

[58] *Twenty-sixth Annual Report of the Ohio State Board of Agriculture for the Year 1871* (Columbus: Nevins and Myers, 1872), p. 298.

[59] *Thirty-fourth Annual Report of the Ohio State Board of Agriculture for the Year 1879* (Columbus: Nevins and Myers, 1880), p. 343.

No reliable statistics concerning land in drainage or length of ditches and drains constructed are available until their inclusion in the United States Census of 1920. Facts concerning a few individual ditch projects are available however, and one ditch constructed in Wood County in 1878–79 indicates the scope of some of the work accomplished. The Jackson Cut-off is a nine mile long ditch dug to divert the headwaters of the Portage River into Beaver Creek, a small tributary of the Maumee River (Fig. 5). The ditch drains parts of Wood, Henry, Putnam, and Hancock Counties. Since its original construction the Jackson Cut-off has been deepened and widened both naturally and artificially until today it constitutes a veritable canal.

The pattern of ditches and major drains was fixed before the turn of the century. Drainage progress during this century has been confined mostly to more frequent underdraining by the individual farmer and the deepening and improving of previously constructed main drains.

THE RURAL SCENE

"A society in process of establishment in a new region seeks to develop the most available resources of that region, at first for itself, then as communications and markets develop, for exchange with other parts."[60] In northwestern Ohio the farmer dominated the scene but not to the exclusion of other closely related enterprise.

"The pioneer was of necessity a woodsman before he could be an agriculturist."[61] During the first half of the nineteenth century hunting and trapping supplemented the farmer's income. In the 1830's coonskins were generally accepted as specie in all commercial transactions along the Maumee.[62] During the latter part of the nineteenth century lumbering supplemented the farmer's income.

Lumbering began in northwestern Ohio in the canal era and was augmented in the railroad era, the end of the former overlapping the beginning of the latter. By 1860 four important railroads radiated from Toledo across northwestern Ohio. Two of these crossed the Black Swamp, one from Toledo to Fremont and the other from Toledo to Lima (Fig. 8). Other railroads fringed the region. Lumbering aided drainage operations, and the railroads helped speed drainage by aiding lumbering. Drainage was a heavy burden on the farmers, and one which they might not have found easy to bear, had not the railroad "afforded a market for the timber which formerly had no value, and rendered the 'winter crop' of timber almost as valuable as their summer crops."[63] In the 1860's the railways of Ohio consumed one million cords of wood annually for fuel alone and an unknown quantity for ties.[64]

[60] R. C. Buley, *The Old Northwest, Pioneer Period, 1815–1840* (Indianapolis: Indiana Historical Society, 1950), I, p. 168.

[61] *Ibid.*, p. 159.

[62] F. Weisenburger, *The Passing of the Frontier, 1825–50,* Vol. III, *The History of the State of Ohio,* ed. C. Wittke (6 vols.; Columbus: Ohio State Archaeological and Historical Society, 1941–43), p. 67.

[63] *Thirty-sixth Annual Report of the Ohio State Board of Agriculture for the Year 1881* (Columbus: G. J. Brand and Co., 1882), p. 266.

[64] *Thirty-first Annual Report of the Ohio State Board of Agriculture for the Year 1876* (Columbus: Nevins and Myers, 1877), p. 509.

In Paulding County, where the swamp forest was densest, wood was made into charcoal for the smelting of iron ore at Cecil and Antwerp (Fig. 5). The ore was shipped from Lake Superior to Toledo, whence it went by canal to the furnaces, which were erected in 1864–65. They had an annual production of some 3,000 tons of ore apiece in 1870.[65] One furnace alone consumed charcoal from about 1,000 acres of woodland annually. The furnaces were closed by the mid 'eighties, and Paulding County lost its chance of being a center of heavy industry; however timber was still abundant enough in 1886 to support fifteen stave factories.[66]

Second in importance to lumbering at first, but destined to surpass it before the turn of the century, was the tile industry of northwestern Ohio. In 1880 there were more than fifty tile factories in the Black Swamp region alone.[67] Not only was the demand for tile great, but it was an increasing demand. The farmer discovered that by decreasing the intervals between his underdrains he got better drainage. This mean using more tile in addition to replacing old tile, and it is still going on. The lumber and tile industries were perfect complements to the dominant way of life in the Black Swamp. Each contributed to the well-being of the farmer.

It was a combination of clearing the forest and draining the land which most completely transformed the Black Swamp into a vast new farmland. The farmer perpetuated the transformation, for the soil was too fertile to allow it ever again to give birth to the forests which once covered it.

What of farming? What kind of land was the Black Swamp? How was it to be used?

Throughout the Black Swamp it was uniformity, not diversity, which was remarkable. The region is a vast lacustrine plain gently sloping to the northeast and drained by numerous sluggish streams. Low, narrow beach ridges of sand and fine gravel; occasional dunes; and scattered limestone outcrops here and there interrupt the otherwise featureless plain. The beach ridges lie at right angles to the general direction of drainage (Fig. 7).

Except for occasional prairies in Wood and Sandusky Counties, a few oak openings, and local variations due to surface aberrations, the deciduous swamp forest dominated the scene (Fig. 11). In 1870 more than half the Black Swamp was still in its natural state.

The soils, a reflection of the vegetation and the surface, also showed marked uniformity throughout the Black Swamp. In the eyes of the farmer the soils counted most, and whenever possible he settled on the better drained soils of the ridges—only to find out later that, after drainage, the yield of the flat land soils was greater. The settler was little aware of the many distinctions we make today between soil series, type, and phase, but he was aware of differences in clayeyness, stoniness and

[65] *Report of the Geological Survey of Ohio,* Vol. I, Pt. I, *Geology* (Columbus: Nevins and Myers, 1874), p. 350.

[66] H. Howe, *Historical Collections of Ohio* (Columbus: Henry Howe and Son, 1891), III, p. 34. Remains of charcoal kilns near Cecil may still be seen.

[67] U. S. Census Office, *Tenth Census of the United States: 1880. Manufactures* (Washington: Gov't Printing Office, 1883), pp. 320–36.

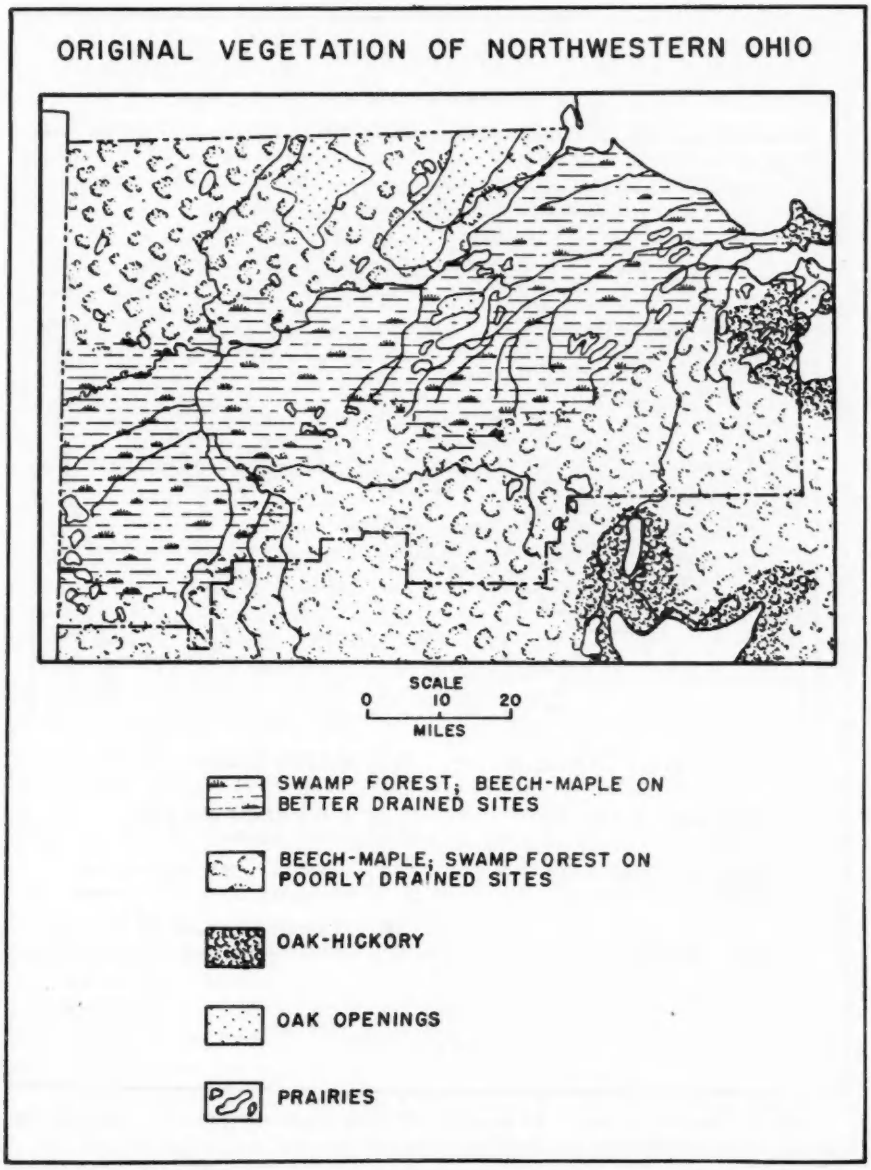

FIG. 11. Original vegetation of northwestern Ohio (after E. Transeau and H. Sampson, "Map of Primary Vegetation Areas of Ohio," in Sitterley and Falconer, "Better Land Utilization for Ohio," Ohio Agric. Exp. Station Mimeo Bull. No. 108, Columbus, 1938, 18).

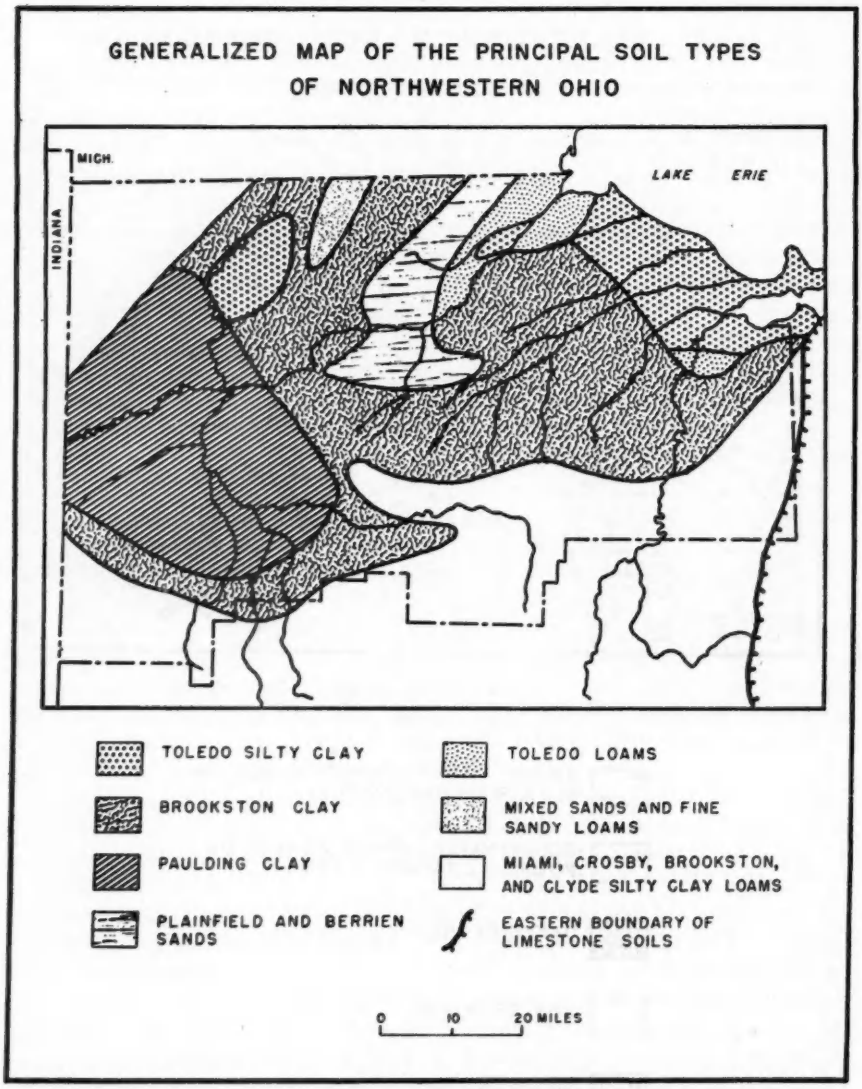

FIG. 12. Generalized map of the principal soil types of northwestern Ohio (after G. Conrey in Sitterley and Falconer, *op. cit.*, 8).

the depth of the topsoil. In 1870 the soils of northwestern Ohio were divided by Klippart into 1) the soil of the Black Swamp proper, 2) the soil of the prairies, and 3) the soil of the sand ridges.[68]

Today the Black Swamp soils are known as Toledo silty clay, Brookston clay, and Paulding clay, roughly in the order of their occurrence from Lake Erie to the southwestern tip of the swamp (Fig. 12).[69] The beach ridge soils are primarily the Belmore loams (L. Whittlesey beach) and the Plainfield and Berrien sands (L. Warren beach). Soil scientists have added little to the general description of the Black Swamp soils since their description in the 1830's by an early geologist. Ignoring minor variations between the remarkably similar profiles of the swamp soils, they may be characterized as having a dark gray to black clayey surface horizon, underlain by a yellowish-gray to brown, plastic, heavy clay horizon resting on dolomitic limestone. The soil texture becomes heavier and heavier with increased distance from the lake shore. All except the Toledo soils contain small limestone pebbles scattered throughout; the Paulding soils are very impervious. When wet the Black Swamp soils are very plastic and sticky; when dry they form into firm clods. Generally speaking, the darker the soil, the poorer the drainage is.

From the beginning of settlement in the Black Swamp the entire agricultural system revolved around corn. Western Ohio has always been corn country. The Black Swamp copied the agriculture of southwestern Ohio rather than that of northeastern Ohio (the Western Reserve) where dairying is and was the dominant economy. The soils of western Ohio are underlain by limestone and are of greater fertility than the sandstone and shale soils of eastern Ohio. The Western Reserve began as corn country, but the diminishing fertility of the soil together with competition from the superior corn land to the west brought about a change to a dairy economy which fitted in better with the qualities of the land and the urbanization of this part of Ohio. On the other hand, corn has been able to maintain itself as "king" in the Black Swamp region because the soils have retained their initial fertility remarkably well, and yields of corn and associated crops have been great enough to permit the region's maintaining a prominent position in the Corn Belt.

FILLING UP THE LAND

The real filling up of the land in northwestern Ohio took place after 1850 and continued until the turn of the century. Between 1850 and 1860 the population of the Black Swamp doubled, although the population of some individual townships did not. In 1860 a few Black Swamp townships contained less than five persons per square mile, and Bartlow, the southeasternmost township in Henry County, had less than one person per square mile. Between 1860 and 1880 the population of the

[68] Ohio Geological Survey, *Report of Progress in 1870* (Columbus: Nevins and Myers, 1871), p. 374.

[69] J. H. Sitterley and J. Falconer, "Better Land Utilization for Ohio" (Ohio State University and Ohio Agricultural Experiment Station, Dept. of Rural Economics, Mimeo Bull. No. 108, Columbus, 1938), pp. 7–11.

Black Swamp doubled again and in some places even tripled or quadrupled (Figs. 9, 10, 13). In 1880 no township had fewer than seventeen persons per square mile. The townships whose population had increased the most were those that had been least populated as, for instance, in southeastern Henry County, southwestern Wood County, and much of southern Paulding County.

The slow settlement before 1870–80 of some of the central and western Black Swamp townships was only partially due to the very dense forests and extremely poor drainage which prevailed in them. Of equal significance was the fact that

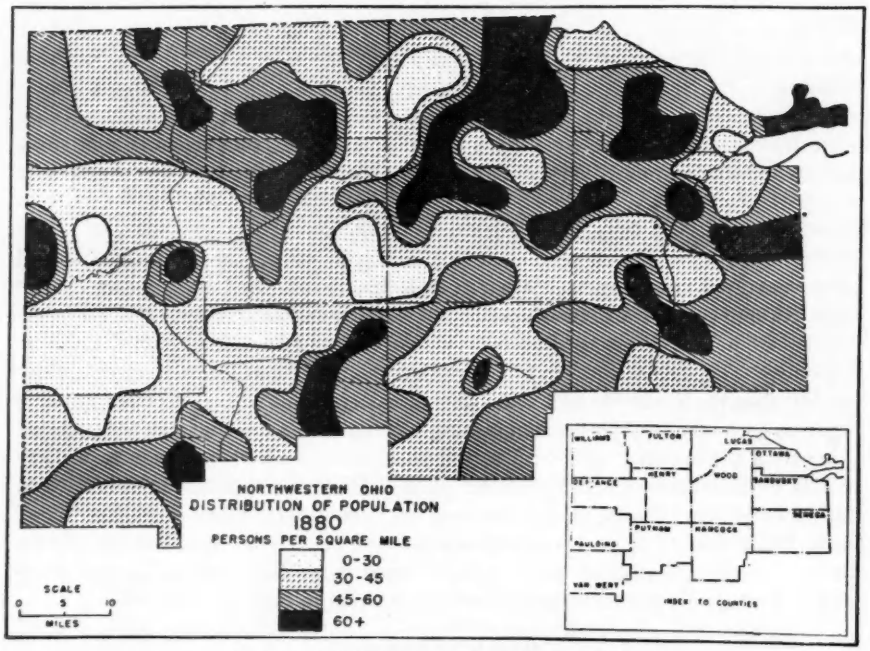

FIG. 13. Distribution of population in 1880.

much of the land in these townships was held by speculators in anticipation of railroad construction.

The population of Bartlow township jumped from three to twenty-nine persons per square mile between 1870 and 1880. During this same decade a second railroad was built through the township, and the Jackson Cut-off was dug in next-door Wood County. The railroad brought about the release of the speculators' holdings and the Cut-off resulted in a marked improvement in local drainage. By 1890 Bartlow township had more than doubled its 1880 population.

In the underpopulated townships of Paulding County, a similar increase could be observed. Between 1880 and 1890 the population of southern Paulding County

increased as much as 400 per cent in some townships (Fig. 14). During this same decade two railroads were built which bisected the county in an east-west and north-south direction. The speculators sold their holdings and a wave of settlers entered the region.

In 1886 gas and oil were discovered in Hancock and Wood Counties giving rise to a short-lived but intense boom. Parts of Sandusky and Seneca Counties were also underlain by the same oil field. The subsequent influx of population was largely urban, but rural population also increased, although at a slower pace than during the previous decade. For a time the oil wells between Bowling Green and

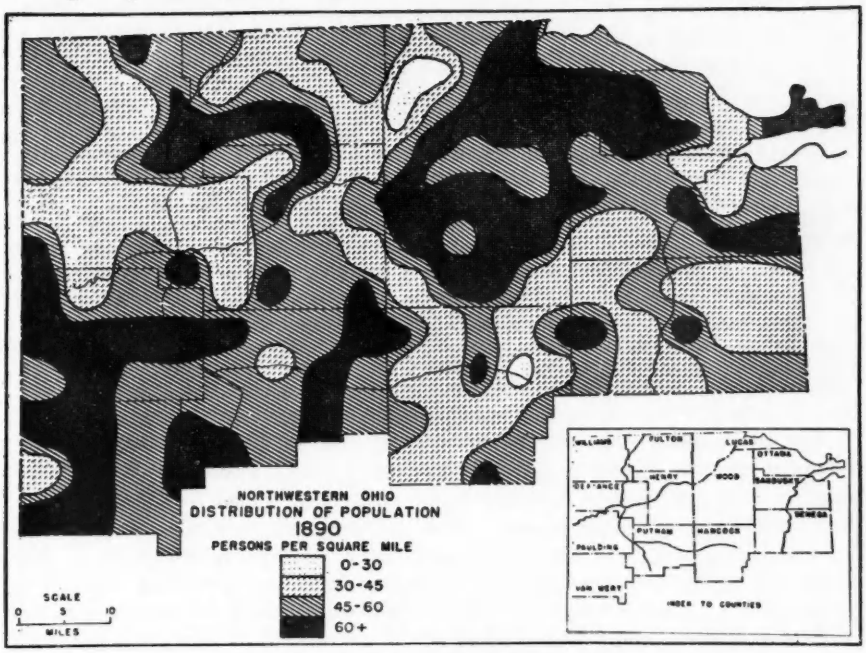

FIG. 14. Distribution of population in 1890.

Findlay were of some significance, but by 1900 the gas and oil fields were almost exhausted. They had given rise to a brief period of glory for the villages concerned, but rural life remained essentially unaffected by the rash of oil derricks which came to dot the countryside.

Rural population reached its peak before 1910 in northwestern Ohio; most of eastern Ohio had gained its peak rural population by 1850; and southwestern Ohio had done likewise by 1880.[70] In some respects the retardation of settlement in the Black Swamp was a definite advantage to the development of the region.

[70] P. Beck, *Recent Trends in the Rural Population of Ohio,* Bull. 553 (Wooster: Ohio Agricultural Experiment Station, 1934): 5.

The rapid settlement of the Black Swamp during the latter half of the nineteenth century coincided with an important era in United States history. The Civil War and the attendant expansion of industry, the building of railroads, the perfection of farm machinery, and the introduction of science into farming all contributed to the betterment of the farmer by increasing the demand for farm products and improving farm productivity. Within a few decades the Black Swamp was transformed from a useless, obstructive morass into one of the most productive regions in Ohio and the Corn Belt. The transformation of the rest of Ohio from wilderness to farm had proceeded more slowly and painstakingly. The farmers of the earlier settled regions of the state often were unable to realize any profits from their labors within their own generation; whereas the Black Swamp farmers reaped a comparatively quick reward from their arduous efforts to clear and drain the land.

SETTLEMENT REACHES THE CLIMAX STAGE

Between 1880 and 1900 settlement entered the climax stage in the Black Swamp. During this period the Black Swamp and northeastern Ohio ceased to be considered a region apart from the rest of the state. In outward appearance it resembled the rest of Ohio at that time. No longer was northwestern Ohio the unimproved, backward portion of an otherwise prosperous and progressive state.

The main changes wrought since the turn of the century are of a lesser magnitude than those changes wrought in the many decades preceding the climax of settlement. Today, as fifty or sixty years ago, the Black Swamp lands are dominantly rural. To be sure, urban and industrial encroachments may be found radiating a short distance out from Toledo, but elsewhere the rural scene prevails.

The Black Swamp has been so transformed that an observer would be hard-pressed to estimate its former extent. Once well within the region he could recognize from the profusion of drainage ditches that here is land that was formerly ill-drained; beyond that the unaided eye would not easily discern any pronounced regional distinctions. The countryside has a neat and prosperous look to it. Large barns, well kept farm houses, abundant farm machinery, and a sky-line interrupted by television antennas are signs, to even the most casual observer, that he is in the midst of good farm land. Nearly all of northwestern Ohio is good farm land, and one does not easily recognize the degree to which the Black Swamp is better farm land than the lands which surround it.

On the other hand, an approximation of the former limits of the Black Swamp may be discerned today statistically. The plotting of certain agricultural statistics by townships reveals the extent to which the Black Swamp has maintained its regional integrity agriculturally (Fig. 15). The most recently available statistical analyses of agriculture on a township base are for 1930 and 1935.[71] Agricultural

[71] Sitterley, *op. cit.*, pp. 38ff. The Black Swamp region is also clearly distinguished on a county unit basis on the map of "Total Cropland as Percent of all Land in Farms," U. S. Bureau of the Census, "Land Utilization—A Graphic Summary," *U. S. Census of Agriculture:* 1950, Vol. V, Pt. 4 (Washington: Gov't Printing Office, 1952), p. 32.

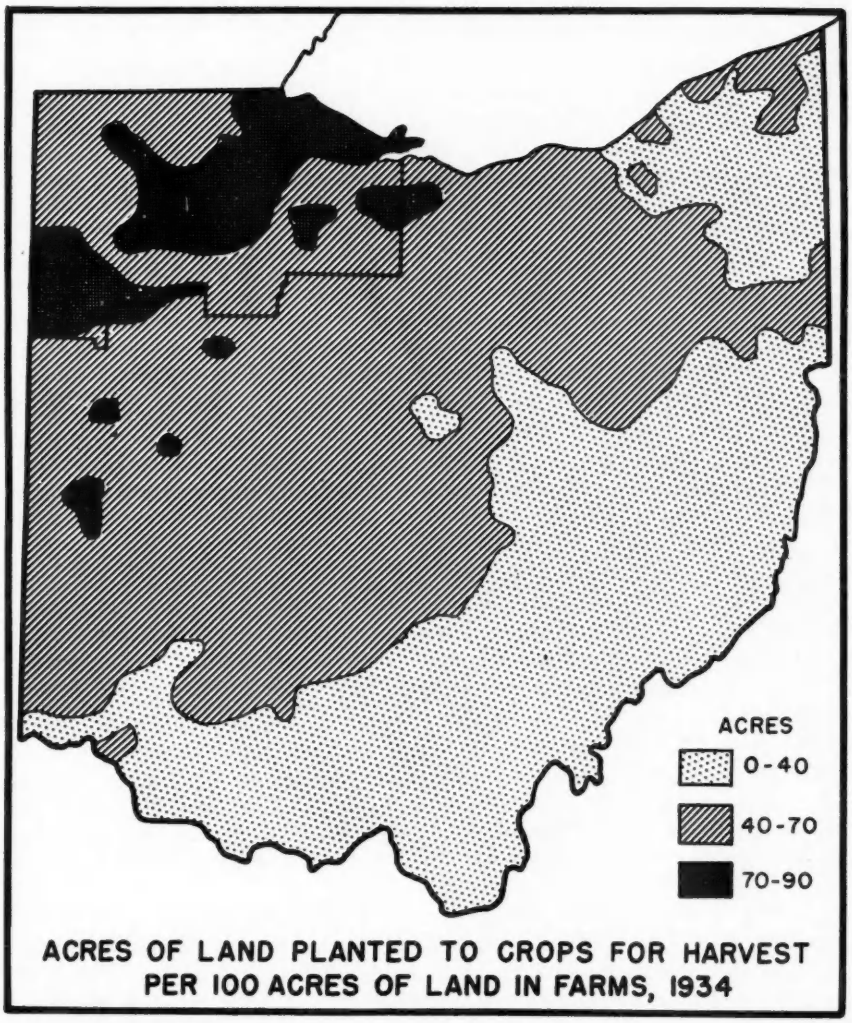

FIG. 15. General boundaries of the Black Swamp as indicated by acres of land planted to harvest per 100 acres of land in farms. Generalized from Sitterley and Falconer, *op. cit.*, 39.

practices within the Black Swamp have changed but little since that time; thus these statistics may still be safely used as indicators of the region's agricultural unity.

In 1930 the Black Swamp was the most completely cropped area in the state.[72]

[72] J. Sitterley and J. Falconer, "Type of Farming Areas in Ohio" (Ohio State Univ. and Ohio Agric. Exp. Sta., Dept. of Rural Economics, Mimeo. Bull. No. 56, Columbus, 1933): 5.

Corn and oats acreages were higher here than elsewhere in the state and pasturage was the smallest. "The lack of sufficient livestock to utilize the abundance of feed crops, the large percentage of lands used in the production of grain crops, and the relatively small acreage of hay and pasture have made it necessary to sell large quantities of feed grains for cash and caused the area to be known as a cash cropping territory."[73] These circumstances still prevail. As early as 1910 the Black Swamp counties as a group led all other sections of the state in the amount of "feedable" crops sold, a position they still hold.[74]

CONCLUSION

A vigorous transformation of the natural landscape has taken place in northwestern Ohio. A vast swamp which formerly dominated the pattern of roads and villages has disappeared leaving in its wake a fertile and productive segment of the Corn Belt. The land is criss-crossed with railroads and highways where once only Indian trails broke through the wilderness; yet the principal cities—Port Clinton, Fremont, Tiffin, Fostoria, Findlay, Delphos, Van Wert, Fort Wayne, Defiance, and Toledo—still persist on the periphery of what was once a swamp (Fig. 1).[75]

The persistence of an initial pattern of settlement in a region formerly characterized by unfavorable terrain conditions (although these unfavorable terrain conditions have long since been removed) is understandable only when the qualities of the land are analyzed together with the abilities of the people occupying that land. Man's abilities, in turn, reflect his cultural heritage and the times in which he lives. That the Black Swamp constituted a barrier to settlement for so long while the surrounding land was rapidly being occupied is in part a reflection of the background of the average American settler of that day. Had another group of settlers, previously experienced in the art of drainage settled the swamp, it may have been transformed into a productive part of Ohio many years sooner than it was. An early Ohio observer wrote:

> . . . a correct knowledge of the uses and influences of drainage has but rarely been possessed by any of our farming population, which is made up principally of emigrants and descendants of emigrants from the more hilly and mountainous states, or from like rolling countries of Europe. . . .[76]

Thus early in the nineteenth century the average American settler, knowing little if anything about the techniques of artificial drainage, avoided the Black Swamp;

[73] *Ibid.* The delineation of the Black Swamp region is clear on the map, "Cash Grain Farms," U. S. Bureau of the Census, "Agriculture 1950—A Graphic Summary," *op. cit.*, Vol. V, Pt. 6, p. 58.

[74] W. Lloyd et al., *The Agriculture of Ohio,* Bulletin 326 (Wooster: Ohio Agric. Exp. Station, 1918), pp. 190, 239.

[75] Bowling Green, the only important city located within the swamp borders, is situated on a sandy beach remnant of glacial Lake Warren. The city owes its prominence to the fact that it is the county seat of prosperous Wood County and the site of Bowling Green State University.

[76] *Twelfth Annual Report of the Ohio State Board of Agriculture for the Year 1857* (Columbus: R. Nevins, 1858), p. 477.

and the population of southeastern Michigan increased at the expense of northwestern Ohio. Those pioneers who chose to settle in northwestern Ohio did so along the edges of the swamp as did the Indians before them. The selection of canal routes served only to underscore the importance of the fringes of the swamp, contributing little to the development of the interior. The first railroads preceded widespread drainage operations and focused their routes on the already established communities. When the Black Swamp was finally successfully drained at the end of the nineteenth century the principal cities of northwestern Ohio were well established. The subsequent changes in the abilities of the people occupying the region have not yet resulted in a re-alignment of the original pattern of settlement.

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THE MISKITO PINE SAVANNA OF NICARAGUA AND HONDURAS*

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THE genus *Pinus,* the most widely distributed and most valuable member of the temperate zone forests of the Northern Hemisphere, extends well into tropical latitudes both in the Old World and in the New World. Natural stands of *P. merkusii* form a part of the man-induced highland savanna association which reaches to within a few miles of the equator in northern Sumatra. This pine has an even more extensive distribution on the Shan Plateau of Burma and Siam, in Indo-China, and on the islands of Luzon and Mindoro in the Philippines. Related species (*P. khaysa, P. insularis*) occupy somewhat higher elevations both on the mainland and in the Benguet hill country of northern Luzon.

The most extensive stands of pines within the tropics, however, are found in Middle America. At least a dozen distinct species are represented among the highland pines which cover much of the more arid portions of interior southern Mexico, Guatemala, Honduras, and northernmost Nicaragua. There are three species of pines on Cuba and Hispaniola. One of these, *P. caribaea,* also occurs extensively in open stands with grass and sedge on the low sand and gravel plains of the rainy British Honduras coast and again on the Miskito (Mosquito) Coast of Nicaragua and Honduras, separated from the highland pine forests by a belt of broadleaf high tropical forest.[1]

THE EXTENT OF THE SAVANNA

The pine savanna of eastern Nicaragua and Honduras seems never before to have been mapped and its very existence has been unknown to many geographers. Interspersed with saw palmettos and scrub hardwoods such as are found along the Gulf Coast and South Atlantic seaboard of the United States, it covers an extensive area of deeply weathered quartz gravels stretching southward from Cape Camarón, Honduras, for some 300 miles to a point a few miles north of Bluefields, Nicaragua, where the southernmost natural stand of pine trees in the New World occurs (Fig. 1). Commercial exploitation of the softwood lumber resource of this coast has only recently been initiated. The designation "Miskito pine savanna" seems appro-

* The field reconnaissance for this study, carried out in Central America during the spring of 1953, was supported by the Geography Branch, Office of Naval Research.

[1] This three-needled Caribbean pine, which also is found on the Bay Islands (Guanaja), the Isle of Pines, in western Cuba, the Bahamas, and in the Petén district of Guatemala, has only recently been recognized by foresters as botanically distinct from the larger-coned slash pine of the southeastern United States. The latter has now been restored to *P. elliottii* as Engelmann originally distinguished it from *P. caribaea* from the Isle of Pines type locality in 1880. Elbert L. Little, Jr. and Keith W. Dorman, "Slash Pine (Pinus Caribaea), Its Nomenclature and Varieties," *Journal of Forestry,* XC (December, 1952) : 918–23.

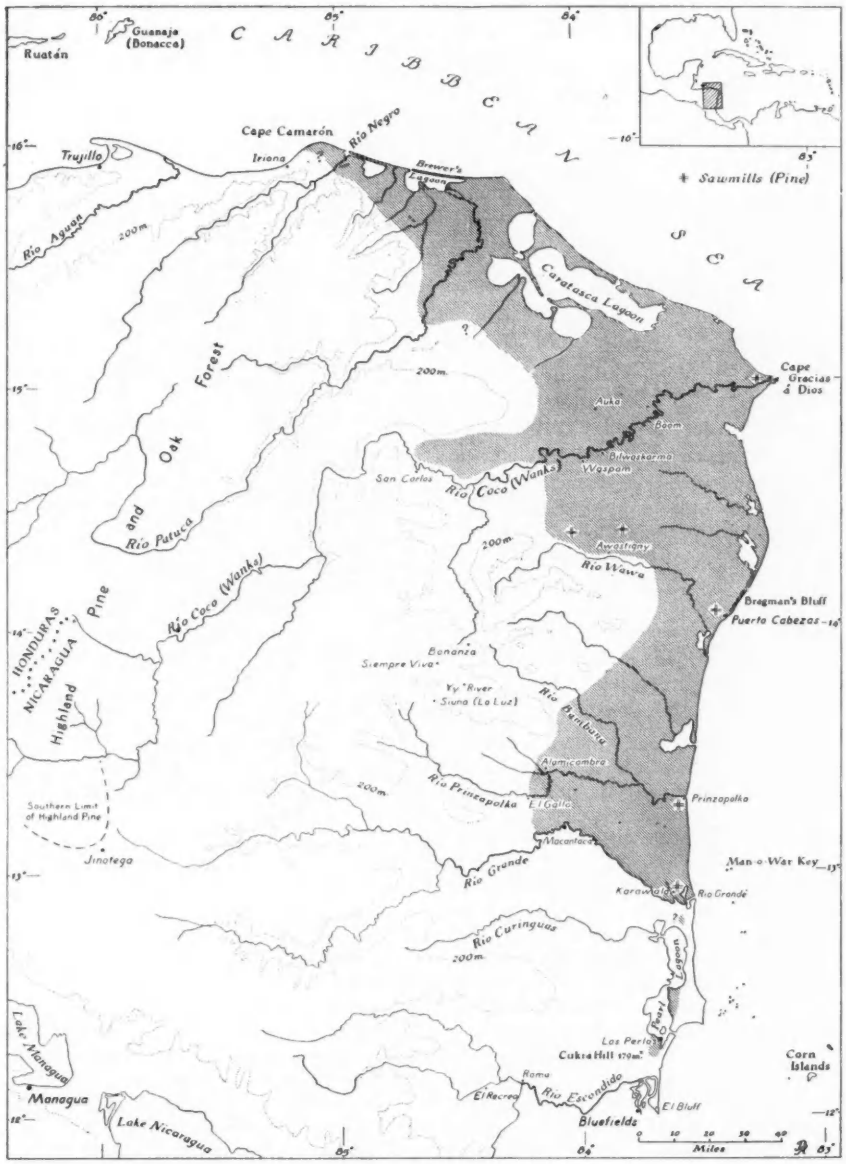

FIG. 1. The extent of the "Miskito savanna" (shaded). Pines are more conspicuous towards the inner margin of the savanna; palmetto and mangrove, toward the beach. Coastal swamp forests and the gallery forests have not been differentiated for the savanna north of the Río Grande. The limits of the savanna north of the Río Patuca is from data supplied by Fred H. Vogel of STICA, Tegucigalpa. (Map drawn by Dr. Brigham Arnold)

priate for this particular plant association as its limits approximate closely those of the territory originally occupied by the Miskito Indians.[2] Their descendants, with a generous admixture of Negro and White blood, are still the most numerous inhabitants of this thinly-settled coast of Central America where both the English and the Miskito languages are more commonly heard than Spanish.

At its most westerly extension on the north bank of the Río Coco (Río Wanks) the Miskito pine savanna reaches more than 100 miles inland from the coast, but its average width is closer to 30 miles. Gallery forests mark the courses of each of the several rivers which cut across the savanna in slightly entrenched channels of which the larger, the Río Patuca, Río Coco, Río Prinzapolca, and Río Grande, are all navigable deep into the interior. Pines occur chiefly on the higher, better drained surfaces interspersed with palmettos and scrub hardwoods which often occur as islands in the savanna. Extensive tracts of seasonally inundated land along the coasts, as behind Cape Gracias á Dios, are treeless marshes. Mangroves and freshwater swamp trees fringe the coastal lagoons and estuaries. Even toward the interior, where pine-covered gravel ridges reach elevations of 500 feet or more, there are fairly extensive, ill-drained flats of grey-blue clay soils supporting only sedges and palmettos.[3] The total area mapped as savanna south of the Río Coco in Nicaragua approximates 2.5 million acres, but of this nearly one-third may be "hardwood islands," gallery, and swamp forests. An area almost as large lies to the north, most of which is within the so-called "disputed territory" which is claimed by both Nicaragua and Honduras, but, except for the immediate banks of the Río Coco, actually administered by the latter.[4]

The northern and southern limits of the coastal Miskito savanna are clearly edaphically conditioned. On the north, beyond low-lying Cape Camarón, the rugged Sierra de Esperanza comes down to the sea to pinch out the gravel shelf. These

[2] Eduard Conzemius, "Ethnographical Survey of the Miskito and Sumu Indians of Honduras and Nicaragua," *Bureau of American Ethnology Bulletin 106* (Washington, 1932). "Mosquito" (Mosquito Coast, Mosquito Territory) has been the spelling generally adopted by the English, originally under the erroneous assumption that the name owed its origin to the insects. I have here adopted the alternative spelling "Miskito" which avoids that confusion. The Spaniards called the Indians "Moscos" and the area "Mosquitia" or "Costa de Mosquita." In general mosquitos are neither particularly numerous nor bothersome in this area today.

[3] There is an early recognition of the association of pines with better drained savanna soils in the remarkable report by a German commission appointed by Prince Carl of Prussia and the Duke of Shoenburg-Waldenburg to investigate the colonization possibilities of the Miskito Coast. A. Fellechner, Dr. Muller, and C. L. C. Hesse, *Bericht Über die im hochsten Auftrage. . . . bewirkte Untersuchung einiger Theile des Mosquitolandes.* Berlin, 1845.

[4] Although the Río Coco was made the boundary under the King of Spain's 1906 arbitration award it was never accepted by Nicaragua. In 1953 Nicaragua police exercised jurisdiction for a few miles north of the Río Coco and there were Nicaraguan schools on both sides of the river. However the only Nicaraguan military post north of the river was at Cape Gracias á Dios, a Nicaraguan settlement which was moved from the mouth of the river to a site upstream on the north bank following the hurricane of 1941. The nearest point clearly under Honduras was Auka, 18 miles from the Río Coco, where there was a Honduras mayor, Honduras money, and people who considered themselves Hondureños.

gravels are not to be found on Bonacca (Guanaja) Island, 60 miles northwest of the cape, where there is a small stand of Caribbean pine. To the south (Fig. 2), high forest replaces the pine beyond Pearl Lagoon as the quartz sands and gravels give way to the striking red, friable clays of the Cukra Hill mafic igneous complex and the basalt flow at El Bluff (elevation 200 feet) which protects the entrance to Bluefields Bay.

The interior boundary or "bush line" (Fig. 3) between pine savanna and high evergreen forest (a dense tropical *monte* as much as 120 feet tall) is almost everywhere sharp. Silicious sand and gravel soils, often containing a mottled, imper-

FIG. 2. Southernmost extremity of the Miskito pine savanna between Pearl Lagoon and Cukra Hill. The surface soil, a sugary quartz sand, is bared in foreground by ruts of old logging road. Mangrove swamp in background.

vious subsoil with iron concretions, characteristically support a savanna vegetation; the high forest occurs on the crumb-structured humic clays of superior water-holding capacities which are found towards the interior.[5] The "bush line" seems not to be related to topography (save possibly near Cape Camarón) and it is some distance inland from it that the land rises above the 700-foot contour. *P. caribaea* stops abruptly with the savanna at the margin of the high broadleaf forest, but is said to recur locally in the arid hill lands of interior Honduras. There, however, the *ocote*

[5] This relationship seems to have been first noted by Hugh Bennett, "The Soils of Central America and Northern South America," *American Soil Survey Association Bulletin,* I, No. 6 (1925) : 69–81. Karl Sapper also recognized the soil as the factor determining the boundary of pine savanna and high forest on the Miskito Coast in "Klimakunde von Mittelamerika," *Handbuch der Klimatologie,* IIH, W. Köppen and R. Geiger, eds. Berlin, 1932. p. 58.

FIG. 3. The "bush line" near Awastigny showing dense growth of tall grasses of sort never found further out on the savanna.

pine (*P. oocarpa*) is the dominant conifer.[6] In British Honduras, too, the Caribbean pine occurs not only on the coastal "pine ridges," but also at elevations of more than 3,000 feet on Mountain Pine Ridge along the Guatemala frontier.[7]

THE ORIGIN AND NATURE OF THE GRAVELS

The origin of the extensive, low-lying gravel surfaces, which petroleum geologists have termed the Puerto Cabezas beds, has puzzled observers. They appear to have been laid down during periods of higher sea level by torrential rivers originating in the much deformed Cretaceous-Tertiary gneissic and igneous highlands at the headwaters of the Río Coco and Río Patuca in northern Nicaragua and southeastern Honduras. Limestone occurs extensively within these forested mountains, and there are thick sections of argillites and quartzites, together with quartz-rich sandstone conglomerates.[8] The absence of softer igneous materials and the preponderance of water-worn quartz gravels and sands suggested to Hershey[9] nearly 40 years ago that the gravels had been reworked by marine action on one or more occasions with the consequent separation of the softer materials from the harder quartz. The virtual absence of bedding planes within the gravels may support this hypothesis. Rapid tropical weathering has obliterated the fossil evidence, but it seems probable that some marine deposits are incorporated within the Puerto Cabezas beds. From the air dendritic gully erosion is here and there conspicuous, especially in the hilly areas of savanna as are found inland from Bragman's Bluff.

There appear to be no persistent terrace levels preserved which can be correlated readily with higher stands of the sea in the past, for their dissection is far advanced. Moreover, late Pleistocene warping and faulting is demonstrable. Remnants of at least two well-marked river terraces associated with the general rejuvenation which led to the entrenchment of the savanna rivers are, however, recognizable in some areas. At Bragman's Bluff, a much-dissected 150-foot wave-cut beach cliff, is one of the few places where pines come down to the sea. At the

[6] Paul J. Shank, "Forest Resources of Honduras," *Proceedings of the Inter-American Conference on the Conservation of Renewable Resources, Denver, 1948.* Washington, 1949. pp. 559–63. Frederick H. Vogel, *Forestry in Honduras.* Institute of Inter-American Affairs, Washington, 1952. 18 pp. The taxonomy of the pines of Honduras remains to be worked out. There is a possibility that there is more than one species on the Miskito savanna. Francisco Altschul, "Informe sobre Territorio de la Mosquitia," *Revista del Archivo y Bibliografia Nacional* (Tegucigalpa), XV (1927) : 576–79, 657–60 mentions two distinct types of pines on the Honduras savannas along the lower Río Patuca, one the "common Baltimore pine," the other "a Rosemary or shortleaf pine" which branches closer to the ground (p. 658). This may refer, however, only to the often-observed correlation between needle length and growing site.

[7] A. F. A. Lamb, "Pine Forests of British Honduras," *Empire Forestry Review,* September, 1950: 219–26. E. E. M. Loock, "The Pines of Mexico and British Honduras," *Union of South Africa Department of Forestry Bulletin 35,* Pretoria, 1950.

[8] Letter from Dr. Roy A. Wilson, Department of Geology and Geography, Rollins College, Winter Park, Florida, July 22, 1953. Dr. Wilson was formerly Geologist with the Gulf Oil Corporation in Nicaragua.

[9] Oscar H. Hershey, "Geological Reconnaissance in Northeastern Nicaragua," *Geological Society of America Bulletin,* XXIII (1912) : 493–516.

Puerto Cabezas pier, four miles to the south, the cliff is perhaps 40 feet high, disappearing entirely toward the mouth of the Río Wawa. The tilted strata exposed at Bragman's Bluff indicate fairly extensive warping of the Pleistocene gravel beds which here have a thickness of at least 75 feet. They are underlain by vari-colored clays and gravel lenses of more consolidated marine deposits (the Bragman's Bluff beds) which are probably of Pliocene age.[10] The lowest visible member of this series is a well-cemented and resistant sandstone which forms a wave-washed ledge several feet wide just above high tide.

In the vicinity of Brewer's Lagoon in Honduras, von Hagen[11] reports old pine stumps standing in depths of water up to 20 feet, evidence that the relationship between land and sea has been undergoing rapid change in the recent past.

Curiously, the size of the water-worn quartz gravels decreases from the Río Coco southward along the coast. At Puerto Cabezas they are marble-sized and larger; at Karawala, they are a pea-gravel; and at Pearl Lagoon, a fine quartz sand. This gradation in size southward is much more conspicuous than any decrease in size from the interior toward the sea and would seem to indicate either that the gravels were laid down by streams quite unrelated to present-day drainage patterns or that sorting by the southward setting shore current was active during periods of marine transgression.

CLIMATE

The Miskito Coast is drenched with rain throughout most of the year. Average annual rainfall probably exceeds 100 inches everywhere within the pine-grassland area, reaching 150 inches to the south in the neighborhood of Bluefields (Table I). Average daily temperatures range narrowly between 76° F. (January–February) and 81° F. (May–June) with sensible temperatures being lowest during the spring months when Trade Winds blow most steadily. Despite the high annual rainfall there is a marked dry season which usually sets in about mid-February and continues into the first week of May. March and April are the driest months, but protracted drought is rare. At Bluefields, for example, over a 21-year period there has never been a rainless month. The average two-month precipitation for March and April at Puerto Cabezas is 4.38 inches; for Bluefields, 5.79 inches; for Iriona, at the northern margin of the savanna in Honduras, 2.44 inches. Critical levels of soil moisture are reached, however, in these months when the herbaceous cover withers and dies and low fires smoulder the length and breadth of the savanna. The occasional showers that fall during March and April, together with the heavy dews, are usually sufficient to induce sprouting in the recently burned savanna grasses and sedges, the roots of which are undamaged by the light burns.

Precipitation values at Puerto Cabezas, on the coast, are remarkably similar to those recorded at the gold mining camps inland 60 to 70 miles within the high

[10] One of the two exploratory wells drilled in 1947–48 near Puerto Cabezas by the Gulf Oil Corporation reached basement at 6,235 feet.

[11] V. Wolfgang von Hagen, "The Mosquito Coast of Honduras and its Inhabitants," *Geographical Review*, XXX (1940): 238–59.

evergreen forest. The annual average for Puerto Cabezas is 129.15 inches; for Siempre Viva Gauging Station (elevation 1,050 feet), 116.22 inches; for Bonanza (elevation 760 feet), 117.13 inches; for Yy River Power House (elevation 900 feet), 130.60 inches; for El Gallo (elevation 100 feet), 123.32 inches. All of these are from records of 10 to 19 years length. A rain-shadow location probably explains the lower figure of 80.56 inches for the 16-year record at Siuna (elevation 575 feet) although there is a suggestion that the rainfall values in the southern interior foothills are somewhat lower than those along the immediate coast. At the El Recreo Agricultural Experiment Station the five-year average is 122 inches or 30 inches less than either Bluefields or Cukra Hill for the same period, both of which lie due east near the coast. On the other hand, recent 12-month records from Karawala

TABLE I

AVERAGE MONTHLY RAINFALL, EASTERN NICARAGUA
(In Inches)

	Bluefields (*1921–26; 38–52*)	Siuna (*1936–52*)	Siempre Viva (*1939–52*)	El Gallo (*1927; 1931–39*)	Bonanza (*1939–52*)	Puerto Cabezas (*1927–50*)
Jan.	10.33	3.27	7.91	7.32	5.76	7.92
Feb.	5.05	1.83	4.43	2.74	3.69	3.37
March	3.34	1.05	1.91	1.67	2.27	2.41
April	2.45	1.21	1.81	1.19	2.55	1.97
May	10.54	7.97	10.13	6.85	11.03	8.04
June	21.19	15.53	15.62	16.98	19.86	18.03
July	26.03	10.68	17.25	20.93	16.57	17.42
August	21.07	9.58	13.63	17.94	13.27	15.41
Sept.	12.48	11.65	13.13	14.83	12.78	15.81
Oct.	12.42	9.56	10.07	14.52	11.69	14.73
Nov.	14.54	4.65	9.20	8.08	8.62	13.53
Dec.	15.77	3.63	10.28	10.17	9.04	11.09
Year	155.21	80.56	116.22	123.32	117.13	129.73

(135.46 inches) and Macantaca (144.97 inches) show somewhat higher precipitation for the more interior location.[12]

Throughout the length of the coast precipitation is highly local in character and a wet year in one section may be a dry year elsewhere. The driest year in the Puerto Cabezas record (1931, 94.81 inches) was followed by a record-breaking 184.93 inches in 1932. In the longer record for Bluefields, extremes of 60.19 inches (1935) and 200.11 inches (1927) have been recorded, the former figure being less than half that for the next driest year, 1939, with 126.40 inches. Extremes at

[12] Rainfall data cited have been obtained from the following sources: Standard Fruit & Steamship Co. and U. S. Weather Bureau (Puerto Cabezas); Neptune Gold Mining Co. (Bonanza, Siempre Viva); La Luz Mines, Ltd. (Siuna, Yy River); Empresas Nolen, S. A. (Karawala, Macantaca); Cukra Development Co. (Bluefields, El Gallo); U.S.D.A. (Cukra Hill, El Recreo); Koppen-Geiger, *Handbuch der Klimatologie*, II H (Iriona).

Bonanza have been 95.32 inches and 141.50 inches; at Siuna, 57.51 inches and 101.53 inches. In general, annual rainfall increases southward along the coast, a fact which must contribute to the more rapid growth of pines and wider spacing of tree rings in the southern extremity of the savanna. A three-year record for Iriona, Honduras, averages 98.78 inches, which compares with 129 inches for Puerto Cabezas and 155 inches for Bluefields. South of Bluefields, where the mountains come down to the sea, the annual precipitation is even greater, exceeding 250 inches at San Juan del Norte on the Costa Rican frontier.

A single precipitation maximum which usually occurs in July (at Bonanza and Siuna in June) is characteristic throughout the savanna. In contrast, on the "banana coast" of Honduras beyond Iriona, pronounced November maximums are registered at all stations.

Although hurricanes occur with much less frequency than in the Antilles, they are nevertheless a conspicuous climatological feature of the Miskito Coast. Most tropical disturbances occur in late September and October, at the end of the Caribbean hurricane season. Occasionally one strikes at the beginning of the season, in late May or early June. From mid-June to mid-September hurricane development centers much further eastward in the Atlantic Ocean and the tracks of those storms which enter the Caribbean area lie well to the north of Cape Gracias á Dios.

SAVANNA AND FOREST SOILS

The Miskito Coast is probably the rainiest area of its size in the New World with a savanna-type vegetation. For so extensive a tropical grassland, either with or without trees, to occur under an average rainfall of 100 to 150 inches with so abbreviated a dry season clearly contradicts once more the traditional concept of the "savanna climate."[13] Pines have been described from widely separated areas in the temperate latitudes as being far less demanding of nutrient values than broadleaf trees, but it is by no means certain that this holds true in the tropical pine savannas. Existence of islands of hardwoods within the Miskito savanna on sites similar to those occupied by pine and grass suggest that geology alone does not hold the key to the distribution of vegetation types here.

For the most part, the surface soils of the savanna are a light grey in color, becoming darker where drainage is poorest. Wherever gully erosion has been active, or where ant-hills or hurricane-uprooted pine trees are found, yellow-red subsoil is characteristically exposed at the surface. Neither tree roots nor percolating rainwater can easily penetrate this B horizon, a poorly aerated and mottled gravelly clay. While the quartz gravels in the top layers of the soil are little weathered, being white and hard, they become increasingly iron-stained and crummy with depth. Irregular-shaped iron concretions are sometimes found within the top four to five feet of gravels; with the quartz pebbles they frequently accumulate on the surface like "desert pavement."

[13] Carl O. Sauer, "Grassland Climax, Fire and Man," *Journal of Range Management*, III (1950): 16–21.

The micro-climate at ground level is very distinct as between forest and savanna. The hot tropical sun gets directly to the exposed savanna soils, so raising the surface temperatures as to increase greatly the rate of evaporation, of humus combustion, and of soil development. The breakdown of silicates to clays is accelerated and the clay particles, which under forest conditions would tend to be flocculated by humus, are free to move downward and to accumulate in the subsoil, this process being most rapid in coarse textured soils.[14] With increasing impedance of soil drainage the impermeable horizon would gradually extend upward. Such colloid accumulation would be especially favored on relatively level sites where there is a marked fluctuation in the water table between wet and dry periods or where sheet erosion has clogged the original drainage channels.

While the micro-climate is not a cause, but an effect, of the vegetation cover it must have an important influence on the rate and nature of soil formation and on the perpetuation of a savanna vegetation once that has been established. The basic questions would seem to be "which came first, pine savanna or impeded soil drainage?" and, in either case, "to what extent may man and fire have been involved?"

THE CASE FOR A FIRE-SAVANNA

Where soils have been used for some time, have become depleted, and have been given up, pines are known to establish themselves where few other trees can survive. O. F. Cook long ago suggested that the pine forests of the highlands of Central America with their characteristic herbaceous understory usually are a secondary formation, the aftermath of clearing and burning of mixed montane forests by native agriculturists.[15] It seems highly improbable that the Miskito savanna surfaces were ever farmed extensively, at least in their present highly leached state. Moreover, the native Indians of the region were at best casual farmers who took their living chiefly from the sea and the hunt. Although their cultivations have probably always been restricted to the narrow strips of alluvium along the streams

[14] It would be instructive to know more about the relative fertility and composition of savanna and forest soils where found side by side. Samples of six savanna and two forest soils from the Nicaragua side were subject to laboratory analysis by Dr. Frank Harradine, Division of Soils, University of California, Berkeley. The soils were acid, but not extremely so, the pH ranging from 5.0 to 6.0 (determined by Beckman pH meter glass electrode at saturation). Organic matter (Cx 1.742 per cent) content of the surface soil was surprisingly high: in contrast to the classical relationship within the temperate zone, higher in the forest soils (5.80 and 8.35 per cent) than in the grassland soils (1.67 to 5.00 per cent). Nitrogen content of the two forest soils (0.37 and 0.57 per cent) was much higher than in samples taken a few yards away across the "bush line" within the pine savanna (0.06 and 0.07 per cent). The carbon-nitrogen (C: N) ratio was relatively high (14.5 to 21.9 on pine savanna soils; 8.4 and 9.0 on forest soils), suggesting that the decomposition of humus here may be less rapid than has commonly been supposed under tropical conditions. However, any charcoal particles in the soil would have added to the carbon values so that the evidence for organic matter accumulation is not entirely convincing.

[15] O. F. Cook, "Vegetation Affected by Agriculture in Central America," *U.S.D.A. Bureau of Plant Industry Bulletin 145,* Washington, 1909.

and behind the coastal beach ridges, it appears that they have habitually burned the savannas for as long as anyone can remember, whether to aid in hunting, to improve grazing, or simply for excitement. In more recent times fore adventurers and lumbermen have followed their example. Such fires have not only suppressed the encroachment of broadleaf forest trees, but have also sharply restricted the regeneration of the pines themselves until, with the added pressures from the logging operations, there is a very real concern for the perpetuation of the pines as an element in the savanna association.

These coarse textured Pleistocene surfaces with their low water-holding capacity may always have supported a vegetation quite distinct from that of the primary soils developed on the tertiary rocks of the interior hill lands. Occasional clumps of scrub hardwoods standing as islands in the midst of the pine savannas are possibly remnants of what may once have been a xerophytic broadleaf forest which at one time covered the whole extent of this low and rainy coast.[16] Relative to the "fireproof" high evergreen forest, one can imagine that this lower scrub forest on the gravel surfaces might have been highly combustible. During the dry season, and especially during occasional years of prolonged spring drought, such a forest would have been extremely vulnerable to fire, which, while used by early man as a tool for both hunting and agriculture, must have been quite beyond his control.

Hurricanes, too, must have played an important role in opening up what may have been originally a dense canopy of forest trees, thus increasing susceptibility to recurrent burning.[17] Flames spreading through wind-thrown forest trees or through a standing, but combustible, scrub forest during the dry season would have bared the surface soil and inhibited regeneration of the primary forest dominants. Repeated with sufficient frequency such fires, fanned by the steady on-shore winds of this coast, would have contributed to the eventual degradation and impoverishment of the surface soil through accelerated sheet wash, humus destruction, and leaching with consequent development of clay accumulations under a sand and gravel topsoil. These ill-drained senile soils, so characteristic of the Miskito savannas, may thus be envisoned as the product of forest removal through recurring

[16] Professor Robert L. Pendleton of The Johns Hopkins University who has visited the Miskito Coast offers another possible explanation of the origin of these interesting hardwood islands which deserves further investigation. He writes (personal communication, March 26, 1954): "These islands had been studied by a man who described them to me when I was there. They were believed to be the site of former camps of the Miskito Indians, for such sites would be protected from fire, and the soil had been enriched by wastes defecated, ashes, and other refuse. It was considered that when the growth got too dense, cutting off the breeze which was depended upon to blow the mosquitos and other insects away, the camp was moved to an open part of the savanna. There seemed to be no difference in the texture of the soil, but the color was darker in the "islands," as one would expect, and the reaction according to my informant was nearer neutral. The "island" forest is kaingined, so the soil is useful."

[17] The puzzling occurrence of extensive areas in the uninhabited rain forest behind Pearl Lagoon with single-specie dominants is tentatively attributed by Archie Carr, *High Jungle and Low*, Gainesville, Florida, 1953, to hurricane blow-downs which have opened up the forest canopy and permitted the establishment of a sun-loving secondary vegetation.

burning and subsequent acid soil hydrolysis, the breaking down of silicates to clays, and the interruption of the cycle of mineral nutrients crucial to the maintenance of tropical forest growth. As the soils became progressively degraded, fire-resistant and sun-loving grasses, sedges, and pines, probably less demanding of mineral nutrients, would have colonized the more vigorously, to the eventual exclusion of the more fire-vulnerable growth.[18]

Woodsmen familiar with the area report the existence of occasional pockets of mature pine along the margins of the savanna which are surrounded or nearly surrounded by scrub monte. This suggests to them that the hardwood forest may now be in the process of shading out pine and grass and recolonizing the savanna wherever fire is suppressed. I regret that I was unable to verify this and to observe more closely the relationship of soil to vegetation along the "bush line" during my visit to the Nicaraguan portion of the savanna. Therein undoubtedly lies the answers to many of the questions raised in these pages.

THE ROLE OF DRAINAGE IMPEDIMENT

J. S. Beard, in his general survey of the savannas of northern tropical America,[19] considers the lack of aeration, for which brilliant mottling is sure evidence, to be crucial in the differentiation between forest and savanna soils together with the alternate water-logging and dessication which this poor drainage promotes. In the rainy months water collects in the sandy surface horizon over the clay and the soil becomes saturated, whereas during the dry season the surface completely dries out and the grass and trees, having no deep roots, are subjected to severe dessication. While such drainage impediment is not found everywhere, it is at least widespread within the Miskito savanna. One of the striking characteristics of the pines on the more level sites is the apparent absence of tap roots, indicated by the great number of blow-downs as well as the radial, pad-like root system which is frequently exposed on the surface. For the development of such impervious horizons the acceleration of laterization and the downward migration of clays which the removal of an original broadleaf forest would have promoted can quite reasonably be called upon in explanation.

These impermeable clay horizons actually need not always be considered the normal product of soil weathering under high rainfall and constantly high surface

[18] A similar argument that succession here has been from evergreen forest to pine savanna is to be found in J. B. Kinloch, *Brief Review of the Forest Resources of Nicaragua,* Managua, February, 1950, an unpublished 12-page manuscript in the Library of the U. S. Department of Agriculture, Washington. See also Felix Rawitscher, "Die Erschopfung Tropischer Boden infolge die Entwaldung," *Acta Tropica* (Basle), III (1946) : 211–247. A partially analogous case may be that described by Frank E. Egler, "Southeast Saline Everglades Vegetation, Florida, and its Management," *Vegetatio* (Den Haag), III (1952) : 213–265 in which it is convincingly contended that "the herbaceous Everglades and the surrounding pinelands were born in fires; that they can survive only with fires; that they are dying today because of fires." (p. 227)

[19] J. S. Beard, "The Savanna Vegetation of Northern Tropical America," *Ecological Monographs,* XXIII (April, 1953) : 149–215. Beard, however, was not personally familiar with any of the Caribbean area pine savannas.

soil temperatures. Occasional beds of dirty white volcanic tuff (dacite-andesite pumice, degraded almost to bentonite) also occur within the gravels and where these are at or near the surface (e.g., at the Waspam airstrip) mottling and impeded drainage are frequently conspicuous.

In British Honduras Charter[20] has envisioned *P. caribaea* as a successional species which becomes established only as alluvial soils age and drainage becomes progressively impeded, but which eventually dies out with further impediment of drainage to be replaced by treeless grass and sedge savanna. The implication here seems to be that, given time, all tropical forest soils become degraded sufficiently no longer to support a high forest. This thesis seems highly questionable in view of the known antiquity of the tropical forest of the Amazon and Congo basins.[21] In any event, the Miskito pine savanna, developed on Pleistocene gravels, can scarcely have the great age which would seem to be required to support this argument. We obviously need to know much more about the time factor in tropical soil formation as well as the effect of forest removal on micro-climate and rates of soil development to speak with any assurance here. It appears well established, however, that the tropical high forest is self-perpetuating until man destroys the cycle and the forest-soil system and dissipates the nutrients.

THE PINE-SAVANNA PLANT ASSOCIATION

In general aspect the open, park-like Miskito savanna bears an extraordinary resemblance to the pine flats of Louisiana or Florida. Where pines occur they are usually widely spaced and straight boled with few low branches. Average diameters for mature trees are probably not much over 16 inches, with heights of from 60 to 100 feet. Merchantable stands average from 3,000 to 5,000 board feet to the acre, reaching maximums of 10,000.[22] On the inner margins of the savannas where fires are probably less frequent and soil conditions perhaps more favorable, stumps of up to 36 inches in diameter may be seen. However, the slow-growing timber of the poorly drained soils is more highly prized in the European export market where a knotless, high density, high tensile strength wood is required. The "four-lining" of logs measuring upwards to 20 by 20 inches by 30 feet for the overseas market rather than the sawmill operations has made operations profitable for foreign lumbermen here in the past. Only the coarser-grained wood is sawn into lumber.

[20] C. G. Charter, *Reconnaissance Survey of the Soils of British Honduras.* Port-au-Spain, Trinidad, 1941.

[21] Louis Lauvaudan represents a view widely held by European foresters when, with reference to the rain forest of central Africa, he argues that "there is no connection whatsoever between the quality of the soil and the distribution or luxuriance of the primeval forest which grows on it;" that the soil owes its fertility to the existence of the forest and disappears with it. "The Equatorial Forest of Tropical Africa: Is Past, Present and Future," *Journal of the Royal African Society,* Supplement, XXXVI, April 1937. See also P. W. Richards, *The Tropical Rain Forest; An Ecological Study,* London, 1952, and R. L. Pendleton, "Agricultural and Forestry Potentialities of the Tropics," *Agronomy Journal,* XLII (1950): 115–123.

[22] G. R. Fahnestock and G. A. Garrett, "Nicaraguan Pine (Pinus Caribaea Mor.)," *Tropical Woods,* LV (September, 1938): 1–16.

Most of the pines being cut commercially carry from 80 to 100 tree rings, with 125 rings being close to the maximum reported. Probably more than one ring is produced in some years. In general, the heartwood is a reddish brown, the sapwood lighter colored. Termite damage occurs in about one-third of the trees, some of the worst infected often being left to re-seed cut-over lands, as is done in mahogany operations. Some trees 60 years or more of age may still be under the minimum diameter of 12 inches, yet mature and past their prime and unlikely ever to reach legal size.

The resin content varies greatly from tree to tree, but it is generally quite high. Early English accounts indicate a greater interest in the pines as a source of pitch for the Royal Navy than as a source of lumber. Commercial turpentining ventures were inaugurated in both Honduras and Nicaragua some 30 years ago but the ventures failed, perhaps more because of labor difficulties, theft of containers, fire losses, and transport difficulties than to any lack of resin flow.[23]

In some areas the only non-herbaceous species is the pine, but for the most part the pines are mingled with a sparse orchard vegetation of large, stiff, leathery-leaved brush and low gnarled trees with thick bark, especially *Curatella americana, Micronia* spp., *Byrsonima crassifolia, Calliandra houstoniana* and, less commonly, *Quercus, Crescentia* and *Mimosa*.[24] Clumps of palmetto (*Acoelorraphe?*) may occur with them (Fig. 4), but they are most common on poorly drained soils in the flats and adjacent to the mangrove-fringed coastal lagoons.

Most of the genera of herbaceous plants found in the Nicaraguan portion of the savanna are also represented in the piney woods flora of the southeastern United States. As there, they are characteristically arranged in scattered clumps with bare soil between. *Cyperaceae* are sufficiently widespread that the designation "sedge savanna," which Beard associates with high rainfall areas, would seem to be appropriate.[25] They occur even on well-drained slopes, especially *Rhynchospora barbata* and *Bulbostylis paradoxus* (*Stenophyllus paradoxus*), the latter a peculiar little upright sedge locally called "niggerhead" whose fire-blackened aerial rhizome sheathed with old leaf bases give it something of the appearance of a shaving brush. It occurs most conspicuously on hill slopes where a white quartz pebble pavement mantles the soil surface.

Among the bunch grasses the genera most conspicuously represented are *Trachy-*

[23] According to Dr. N. T. Mirov, Plant Physiologist of the California Forest and Range Experiment Station, Berkeley, chemical analysis of pitch samples collected by me from pines at Karawala, Nicaragua, show a distinctive and much more complex set of turpenes than those found in the slash pine of the southeastern United States. The presence of substantial quantities of phellandrene, carene, and longifolene turpenes emphasizes the distinction between the Miskito Coast pine and the slash pine (cf. footnote 1).

[24] Botanical determinations of species and genera cited in this section have been made by Jason R. Swallen and Lyman Smith of the U. S. National Herbarium, Washington, D. C.

[25] Beard, *op. cit.*, p. 195, considers a sedge savanna as characteristic of swampy conditions of relatively small extent which alternate rapidly with forest and woodland. This does not fit the Miskito Coast situation well.

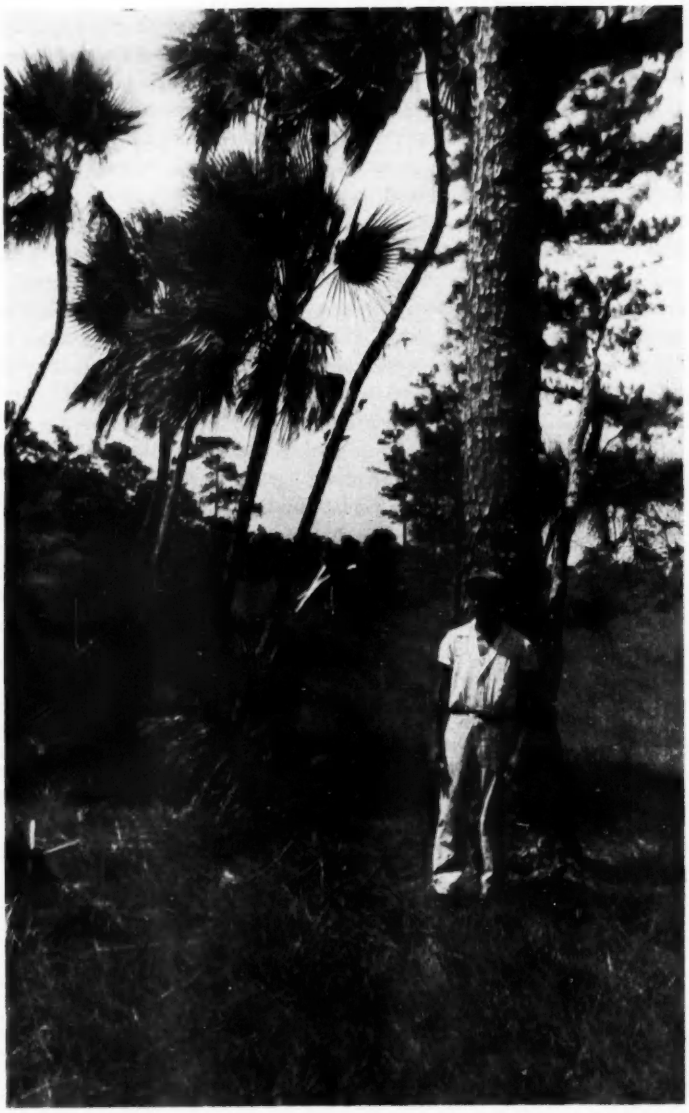

Fig. 4. Miskito Indian boy in front of mature pine growing in association with palmetto palms and short grass.

pogon, Andropogon, Paspalum (grama), *Aristida* and *Leptocoryphium,* possibly in that order. The sward-like gramas are especially on the better soils. Along the margins of the high forest, in the "tension zone" between savanna and monte, these shorter grasses give way to the tall *Arundinella deppennae, Ischaemum latifolium,* and a species of *Tripsacum* locally known as *"teocinte."* These head-high grasses of superior grazing value may well be pioneers in the process of invasion of the savanna by the monte. It would be useful to know in detail the nature of the soil transition from low grass savanna to high grass savanna to forest. The pines which occur with these tall grasses along the "bush line" characteristically are superior specimens of larger than average diameter, perhaps because fires are less frequent here than in the short grass-sedge areas.

Everywhere the high forest environment, damp, dark and insect-infested, contrasts sharply with the open sunny landscape of the pine-bunch grass-sedge savannas where monkeys and parrots chatter incongruously amidst the upper branches of orchid-festooned pine trees. Within the monte or "mahogany bush" there is an extreme diversity of species. Palms and bamboos are prominently represented as are such economically significant rain forest genera as *Swietenia* (mahogany), *Cedrela* (Spanish cedar), *Calophyllum* (Maria), *Carapa* (*cedro macho*), *Hieronyma* (*nancito*), *Dalium* (*comenegro*), and *Castilla* (*caucho*).[26]

STOCK-RAISING ON THE SAVANNA

Although stock-raising has never been of any real importance on the Miskito savannas the possibilities of developing it into a profitable export industry suggested itself to observers from earliest times. Hodgson noted in 1757 that "cattle and mules might be had very cheap in the savannahs, which with proper treatment would make fine pasture," adding that Jamaica's mule requirements could be wholly supplied from this coast.[27] The need for more vessels to carry cattle slowed up the evacuation of English settlers from Cape Gracias á Dios to Belize and Grand Cayman as called for by the Treaty of Madrid in 1786.[28] Cape Gracias, in fact, continued to make small shipments of cattle to Belize throughout the nineteenth century. At present the small amount of beef raised on the savanna goes to supply the gold mining camps at Bonanza and Siuna, a considerable portion of the stock coming from the Honduras side of the Río Coco. Exportation of livestock has

[26] For an extraordinarily vivid description of this forest as it exists behind Pearl Lagoon, Nicaragua, see Archie Carr, *op. cit.*

[27] Col. Robert Hodgson, *Some Account of the Mosquito Territory contained in a memoir written in 1757 . . . etc.,* 2nd ed. Edinburgh, 1822. p. 37. In 1774 Edward Long wrote that "the beef of the savannahs near Cape Gracias á Dios is superior to the North American, and takes salt well." *The History of Jamaica.* London, 1774. p. 318. According to Young the English stock-raising efforts had ended in failure because the Indians had killed the settlers' cattle as well as slaughtering their own indiscriminately. Thomas Young, *Narrative of a Residence on the Mosquito Shore. . . .* London, 1842.

[28] Pedro de Obregon, "Diario de Occurrencias Particulares . . ." in *Relaciones Históricas y Geográficas de America Central,* Manuel Serrana y Sanz, ed. Madrid, 1908. VIII, pp. 221–27.

been a presidential monopoly in Nicaragua and this may have tended to restrict expansion of the industry. Distance from markets has to date restricted the growth of a livestock industry more than any possible nutritional deficiencies in the herbage, which is probably low in phosphorous and without apparent source of lime.

The sedges and grasses appear to have a high palatability for the better part of the year, the tendency toward rankness and coarseness being serious during the latter part of the rainy season. Cattle are said to be in the best shape at the end of the dry season, and this is the breeding season. In Louisiana, where conditions are somewhat similar, the nutritive value of grass and sedge (especially protein and phosphorous) is said to be highest when the leaves are young, decreasing as leaves mature; calcium content, on the other hand, is highest in full leaf and mature leaf stages of growth.[29] Some Miskito Coast ranchers feel that fencing and closer grazing might be beneficial. Others have experimented with plantings of *Hyperhennia rufa* and other introduced pasture grasses with some success. Water is available throughout the year from the numerous full-flowing streams which cut across the savanna, together with the succulent grasses which grow on the alluvial bottoms even when the savanna upland is in its poorest condition. Jaguars, the principal predators, are not a serious menace. The introduction of Zebú blood for crossing with the black creole types of cattle has not yet been attempted.

EARLY TRADE AND SETTLEMENT

As early as 1632 a trading station had been established among the Miskito Indians at Cape Gracias á Dios by English adventurers from the Puritan establishment on Old Providence Island, some 300 miles to the eastward.[30] From the beginning relations between natives and traders were amicable and a sort of symbiotic relationship soon grew up, nurtured in part by mutual antagonism towards the Spanish, that survived for better than two centuries. The Indians were superlative boatsmen and their talents were early and effectively channeled by the English into small-scale raiding expeditions against the thinly held Spanish settlements both north and south. Hijacked cacao, gold, and slaves were exchanged with the English residents of the "Shore" for gunpowder, rum and calico. From time to time Miskito Indians were taken to Jamaica, as in 1688 when they were used by the English as auxiliaries to put down a slave rebellion. Others shipped out on English and Dutch pirate vessels, of which there were few that did not carry at least one Miskitoman as a "striker" to supply fish or turtle for the mess table.

While enough food seems to have been grown to meet local requirements commercial plantation agriculture for export played little part in the British scheme of things. At the close of the 18th century the slaves from Colonel Hodgson's mahogany works at Bluefields began to be used to cultivate cotton on Corn Island; earlier

[29] Robert S. Campbell and John T. Cassady, "Grazing Values for Cattle on Pine Forest Ranges in Louisiana," *Louisiana Agricultural Experiment Station Bulletin 452.* Baton Rouge, 1951. p. 8.

[30] A. P. Newton, *The Colonizing Activities of the English Puritans.* New Haven, 1914.

a few small sugar plantations had been established on the banks of the Black River (Río Negro). There had been an early, but brief, interest in wild pita or "silk-grass" (*Aechmea magdalenae*) as a fiber plant, but the most important local products exported were sarsaparilla root, mahogany, hawksbill turtle shell, salted green turtle meat, and mules.[31] Although no logwood (Campeche wood) grew on the Shore, its bar-protected lagoons and friendly Indians made it the nearest place of refuge for the Baymen who were cutting this wood under Spanish surveillance at Belize and Yucatan.[32] The occupation of the northern portion of the Miskito Coast, and especially the Black River settlement, was closely related to the tides of fortune of these activities. By 1770 mahogany had replaced logwood as the principal export of Belize. The great development of cabinet and furniture making throughout Europe at this time must have encouraged the expansion of mahogany operations on the Miskito Shore, too, until the English evacuation.

As a matter of fact, the principal reputation of the Shore seems to have derived in those days from the salubrity of its climate. From the beginning it served as a sort of sanitarium for the planters of Jamaica whenever the "flux" or tropical fevers became oppressive.[33] In this respect, no distinction seems to have been made between the forested lands about Bluefields Bay and the open savanna country to the north. Indeed, as recently as 50 years ago New Orleans steamship companies were advertising the health attractions of "fever-free Bluefields." The reputation of the modern town (1950 population: 8,016) as a tropical pesthole is quite undeserved and probably stems from the association of the term "Mosquito" (Miskito) with the extraordinarily high rainfall of the area.

The British evacuation of 1786 was at best a half-hearted affair and the influence of the Crown on the Coast diminished but little. No longer a privateering base, its economy in the 19th century depended increasingly on the mahogany logs which were rafted down to the sea on its many rivers. Large-scale colonization plans,

[31] The export duty on sarsaparilla alone was said to more than pay the small expenses of the English administration on the Miskito Shore. Sarsaparilla exports in 1757 were 120,000 pounds (Hodgson, *op. cit.*, p. 17); in 1769, 200,000 pounds. Much of this went to Holland (Robert White, *The Case of the Agent of the Settlers on the Coast of Yucatan and the Late Settlers on the Mosquito Shore . . . etc.* London, 1793, pp. 47 ff). Mahogany from this coast, while plentiful, was coarser grained because of the higher rainfall than that from Belize and so less valued.

[32] The 1,124 persons reported residing under the British Resident Commissioner's jurisdiction on the Miskito Shore in 1757 included 133 white men and 21 white women and children (Hodgson, *op. cit.*, p. 15).

[33] Thomas Jefferys, *The West India Atlas.* London, 1775. p. 16, refers to the Miskito Shore as "one of the healthiest and most beautiful spots in the world." For many years the West India Pilot of the Royal Hydrographic Office carried the statement: "Be the cause what it may experience attests that men usually live here to a greater age than in Europe." A 1699 account, one of the earliest for this coast, describes a 103-year-old Englishman living at Bragman's "who can still walk out 20 or 30 miles a-hunting and bring back a deer on his back . . . which argues much for the healthfulness of that country." M. W., "The Mosquito Indian and his Golden River," *Churchill's Collection of Voyages and Travels,* 3rd ed. London, 1746. pp. 297–312 (reference p. 302).

both English and German, ended as fiascos. The scheming to capture the Atlantic terminus for the proposed Nicaraguan Canal led to the establishment under British aegis of the preposterous "Mosquito Kingdom" in 1860, but by this time the United States had begun to display a diplomatic concern for the area, the end result of which was assumption of complete jurisdiction over the coast south of Cape Gracias á Dios by Nicaragua in 1894. An influx of American speculators and tropical tramps followed for whom this conveniently accessible Central American coast seemed a likely place to set "Manifest Destiny" into operation.

PINE LUMBERING ON THE SAVANNAS

First rubber and bananas, then gold and mahogany, and most recently pine lumbering have provided brief fillips to the economy of the Coast, but resource depletion and plant disease, together with unstable governments, banditry and chronic labor shortages have never permitted any of the incipient booms to get really off the ground. Bluefields, especially, was the center for these hopes at the turn of the century. With an English language daily newspaper and steamship service to New Orleans or Mobile usually twice a week it seemed on the verge of becoming a major American outpost in the Caribbean. Freedom from yellow fever was one of its most publicized attractions. "We need only a Rhodes," wrote a local editor, "to make us the counterpart of Johannesburg."[34] But those days of hope are gone and, with their locational advantages forfeited to Colon, Bluefields and the Miskito Coast are today among the least known, least visited, and most forgotten parts of the entire Caribbean area. Place names like Kansas City, Chicago Farm, and Mississippi bear witness to the visions of American speculators in tropical agriculture, but only liana-covered secondary forest trees are left to mark their locations.

The pine forests of the Miskito Shore interested early observers more as a potential source of tar and turpentine and as a grazing resource than for their lumber. The wood supplied a convenient cooking fuel, of course, and it appears to have been used extensively for torches in night operations in the mahogany works.[35] Hodgson noted in 1757 that the pines "make good boards, planks, scantling and timbers but are too heavy for topmasts."[36] The curious fact that the wood often would not float was attributed to its high pitch content.

Although there appears to have been some sawn lumber shipped from Cape Gracias á Dios to Jamaica in the eighteenth century the first important commercial exploitation of the pine resource dates from much later. An 1892 account reports that there was a small American-operated pine mill on the Río Wawa, per-

[34] *The Recorder*, Bluefields, November 27, 1897.

[35] In British Honduras it was said that "but for the pine torches the hauling of mahogany, which, on account of the heat and the flies (mosquitos) takes place chiefly at night, could not be carried on." D. Morris, *The Colony of British Honduras, Its Resources and Prospects.* London, 1883. p. 57.

[36] Hodgson; *op. cit.*, p. 26. He describes two sorts of pines, "one very full of tar and turpentine, the other more free from it and whiter."

haps the first on the coast.[37] Mahogany, not pine, was the wealth of eastern Nicaragua and Honduras in those days and the history of the pine industry is intricately interwoven with complicated litigations over mahogany concessions, chiefly within the Nicaragua savanna. The George D. Emery Company of Boston in 1894 had obtained what amounted to a monopoly for cutting timbers of the East Coast of Nicaragua by consolidating two earlier concessions made by the puppet government of the Mosquito Territory, one to the Canadian J. C. Crookshank and the other to the Emery interests (in 1885 on the Río Grande).[38] In their eight years of operations under the Nicaraguan government, until a legal suit forced a close-down, the company had exported logs from the Río Grande to Boston at the rate of 1,000 logs a month. It had employed some 1,300 men in the works, mostly Indians, but including as many as 100 Americans. The company's operations in Colombia were dove-tailed with those in Nicaragua and ships from Cartagena or the Río Sinu often stopped at Río Grande to complete a load.

The Emery case was not settled until 1909 when the company withdrew from the country for a cash settlement of $600,000. Meanwhile several short-lived Nicaraguan governments had made conflicting grants to other groups for the specific purpose of developing the pine lumber resources of the coast which, by one interpretation, were not within the compass of the Emery grant.[39] In 1905, the Louisiana-Nicaragua Lumber Company, controlled by Lomax Anderson of Moss Point, Mississippi, had obtained an "exclusive" 50-year right to the pine forests of northeastern Nicaragua, together with a similar concession from the Honduras government to cut pines north of the Río Coco. By 1906 a small sawmill had been completed at Cape Gracias á Dios. Earlier, in 1903, the Dietrick syndicate (United States and Nicaragua Company) of Pittsburgh had obtained a vaguely worded concession to "mineral lands" south of the Río Coco which included a portion of the pine flats. With it went a monopoly of all steam navigation on the river and of all wharf and warehouse construction at the new town being erected at the Cape. Conflict among the Emery, Anderson, and Dietrick grants resulted in a hopeless mass of red tape and confusion and, aside from the earlier Emery mahogany exports, little lumber production. The Dietrick group for a time was very active at the Cape (renamed briefly Port Dietrick) where the population of 600 included over 50 Americans. The group later became involved in promotion of "plantation

[37] Courtnay DeKalb, "Nicaragua: Studies on the Mosquito Shore in 1892," *Journal of the American Geographical Society*, XXV (1893): 236–88, specifically p. 259. An anonymous 1780 "Report on the Miskito Country" in *Collection of the New York Historical Society*, XVII (1884): 419–31 tells of "some sawmills" being erected 100 miles up the Río Wanks "with a view of procuring lumber for the Jamaica markets." p. 426.

[38] Consular Reports, Bluefields, 1898 (#25–2, Feb. 7, 1898). National Archives, Washington, D. C.

[39] A wealth of materials on the early 19th century lumber concessions in Nicaragua and Honduras is to be found in the State Department papers in the National Archives, Washington, D. C. In the following reconstruction I have used these documents: Cape Gracias á Dios Post Dispatches, 1903–08; State Department Decimal File 817.52/34; 817.602; 817.617; 924.200; 924.267; 924.349.

lands" for sale to American investors along the Río Grande where it had obtained a "two-and-a-half-million-acre" grant with a promise to purchase certain government bonds. Sales had been made to 25 new "plantation companies" before the government finally renounced the original grant in 1914. Yet another grant, to a Managua Italian named Cagliaris, in 1908, was for the exploitation of the pine forests south of the Río Prinzapolca, but this title, too, was long fogged by political upheavals and revolutions.

Modern commercial pine lumbering dates from 1921 when a group of New Orleans and Slidell, Louisiana, lumbermen joined forces with the Vaccaro Brothers (who were later to found the Standard Fruit and Steamship Company) to establish the Bragman's Bluff Lumber Company, purchasing timber rights to 80,000 acres of land behind Bragman's Bluff "adapted to cattle raising or on which there are pine trees." Although there were conflicts with Indian Reserve land claims, the American company poured some five million dollars into the development, establishing the new town of Puerto Cabezas (named for a Nicaraguan patriot) and building deep-water port facilities and some 100 miles of railroad to service both the lumber operations and the new banana plantings along the alluvial bottoms of the Río Wawa.[40] A modern sawmill was moved here intact from Louisiana and a planing mill established. Exports of sawn lumber began in 1925. Revolutions and civil war greatly disturbed operations, more particularly in the banana business, and after 1931 banana plantings were abandoned.[41] In recent years the pine lands held in fee simple have been leased on a stumpage basis to the Robinson interests of New Orleans who have built an extensive network of logging roads throughout the savanna to the banks of the Río Coco at Waspam (Fig. 6) and Bilwaskarma. The town of Puerto Cabezas (1950 population: 3,464), with wharf and waterfront railroad facilities, remains the property of the Standard Fruit and Steamship Company (successors to the Bragman's Bluff Lumber Company). Facilities are leased both to the lumber company (now the Nicaragua Longleaf Pine Lumber Company—"Nipco") and to the two major gold mining interests in the interior at Siuna and Bonanza, which import supplies through "The Port." They are flown to the mines on cargo planes which use either the large new American-built Puerto Cabezas airfield, or the strip at Alamicambra at the head of barge navigation on the Río Prinzapolca. When the modern "Nipco" sawmill at Puerto Cabezas (capacity 60,000 board feet daily) burned to the ground in the spring of 1953 all mill operations were transferred to two portable mills located some 60 miles inland and closer to the remaining stand of merchantable timber.

There are two other smaller pine operations on the Nicaraguan section of the

[40] "A Magnificant Pine Operation in Nicaragua," *The Lumber Trade Journal* (New Orleans), Jan. 15, 1928: 22–23.

[41] The annual report of the Nicaragua Customs Service for 1929 referred to the Standard Fruit banana operations as follows: "The lands have not proven so fertile as supposed, the heavy rains washed out the bridges, the banana disease appeared and the production of bananas was very small for the acreage planted." *Report of the Collector-General of Customs*, Republic of Nicaragua, Administrator of Customs, Managua, 1930.

coast. Waddell's Prinzapolca mill is cutting on the Río Bambana while Empresas Nolen, S. A. (Standard Export Lumber Company) at Karawala has a 45,000 board feet capacity mill which is being supplied from operations behind Macantaca on the Río Grande. Because of the difficulty of crossing the shallow bars at the river mouths for all except the smallest vessels shipments are often loaded at Man-o-War Key, 12 miles off the coast.

North of the Río Coco commercial pine lumbering seems not to have been tried prior to 1946 when an American group set up a mill at Brewer's Lagoon and began to work a large concession of "longleaf yellow pine."[42] The difficulties of crossing the treacherous bar, together with the fact that the standing timber was disappointingly poor due to hurricane damage, led to early abandonment of the operation. The best stands of pines remaining on the Coast, however, lie north of the Río Coco within the so-called "disputed territory," but commercial cutting in the area does not appear likely to be politically feasible within the near future.

THE FUTURE OF THE PINE RESOURCE

The life expectancy of the coastal pine forests of the Miskito Shore cannot exceed a very few years. While the lumbermen have been cutting as much as 40 million board feet annually, termites, beetles, windfall, and, especially, fire have continued to take their toll. The importance of wind-fall is evidenced by the traces of large numbers of uprooted trees, all similarly aligned, that are seen in many areas. There is little fire damage to mature trees for crown fires are apparently unknown although root and basal trunk scars from burning grass may provide access to termites. The most serious effect of the fires is the killing of the young pine seedlings on which the regeneration of the forest depends. In many cut-over areas, moreover, only a very few small, non-merchantable trees have been left standing as seed stock for the future. Replanting, although required by law, is unnecessary, for the pines are prolific seed producers (Figs. 5, 8). What is needed is complete fire protection of cut-over areas for from five to ten years or until the natural regeneration has reached eight to ten feet in height. A simple system of firebreaks would accomplish much towards this end for often a narrow foot trail is sufficient to stop the flames.

At present there is no forester, no fire prevention crew, and no inventory of the merchantable timber still standing on this low-lying Caribbean coast of Nicaragua and Honduras. Like sarsaparilla, turtle, rubber, mahogany, and bananas before, pine lumbering, which has revived the economy of the coast in recent years, will soon drop off to insignificant levels. Under some semblance of a management program, a second crop of timber trees might be ready in another 50 to 75 years. The alternative would seem to be continued destructive fires and continued im-

[42] Jack Harper, "Lumber Heaven—Three Men Think They've Found It," *The Southern Lumber Journal*, July, 1947: 20ff. The president of the company, a Palatka, Florida, lumberman, had cruised the tract by air to select the most favorable site to start cutting. He was quoted as saying: "In 40 years of sawmilling in the South this is the best yellow pine [*sic*] I have ever seen."

poverishment of the pine resource.[43] A few small protected areas, as around the Moravian Church's mission hospital at Bilwaskarma, offer abundant evidence of the pine tree's capacity to reproduce itself here when given the chance.

LUMBER AND BANANA EXPORTS

Although the first pine shipments from Puerto Cabezas were logs destined to Honduras for use on Standard Fruit Company banana properties there, export markets for sawn lumber were rapidly developed, first in the Caribbean and later in Europe. Nicaraguan exports reached 9.6 million board feet in 1929, dropped off sharply during the early 'thirties and reached 8.2 million board feet ten years later,

FIG. 5. Unusually dense stand of young pine near Karawala. This area was probably cut over early, then protected from fire.

when shipments were three times the value of Nicaragua's mahogany exports. During World War II operations slackened, but with expansion of the Puerto Cabezas operations and those at Prinzapolca and Karawala pine shipments had climbed to a record 39.8 million board feet by 1952, valued at over two million dollars (U.S.). Of this, about two-thirds moved out of Puerto Cabezas (Fig. 7); the other third, from Karawala and Prinzapolca. In general, the large timbers of finer-grained wood move to European markets, the sawn lumber from coarser-grained stock to local Caribbean markets, especially Cuba, Jamaica, and Panama.

[43] Report of the FAO Mission for Nicaragua (United Nations Food and Agriculture Organization), Washington & Rome, 1950, and The Economic Development of Nicaragua (International Bank for Reconstruction and Development), Baltimore, 1952, both urge strongly the introduction of modern forest management principles to the wasting pine forest asset of the Caribbean coast.

In Nicaragua's economy exports of coffee, gold, cotton, and, occasionally, sesame seed have all ranked above pine lumber in value in recent years. Honduras' exports of pine are nearly double those from Nicaragua (in 1950–51 they accounted for ten per cent of that country's exports by value), but all of this comes from the highland pine forests of the arid interior. These extensive tracts of pine, extending into Nicaragua for some 75 miles in the neighborhood of Jinotega (Fig. 1), make it certain that Honduras production can be maintained for a considerable number of years even in the face of careless cutting methods and fire damage.

In neither Nicaragua nor Honduras are mahogany exports, once with bananas of major economic significance, any longer of much importance. The more readily

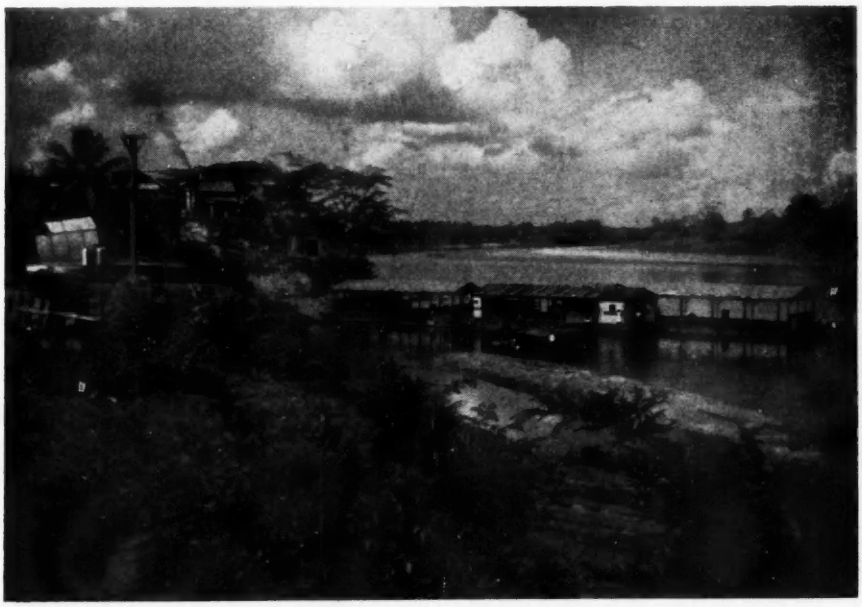

FIG. 6. The Río Coco at Waspam. Banana barges, in foreground, go upstream to San Carlos for fruit which are shipped from Cape Gracias to Tampa, Fla., on regular bi-weekly schedule.

accessible stands tributary to the navigable rivers on the Caribbean coast have been exhausted. Moreover, the system of concessions, in Nicaragua at least, is said to have discouraged investment in access-road construction. The revolution and banditry in 1925 and later seriously affected mahogany operations in both countries and by 1930 most of the large American concerns had pulled out.[44] With the return of peace and prosperity there has been some revival of the trade, with exports of ma-

[44] One U. S. mahogany concern still floats several thousand logs a year down the Río Coco from its upper reaches to Kisalaya (above Waspam) where they are sorted, made into rafts and taken down to Cape Gracias. The former sorting point at Boom, lower down on the river, has completely silted up.

hogany and cedar together reaching perhaps one-third the value of pine exports. Plantations of mahogany, cedar, and teak on abandoned banana lands along the Río Escondido by the United Fruit Company show much promise, but important production cannot be expected from these plantings for some years.[45]

Neither the United Fruit Company nor Standard Fruit and Steamship Company have grown bananas on this coast for 25 years. The former once had extensive properties both behind Bluefields and Río Grande in Nicaragua and between Cape Camerón and Trujillo in Honduras. Panama disease and Sigatoka disease are the twin culprits. The former, a soil fungus, is the more serious. It can only be fought by large-scale flooding of the land for periods of 5 to 6 months, as is being done in

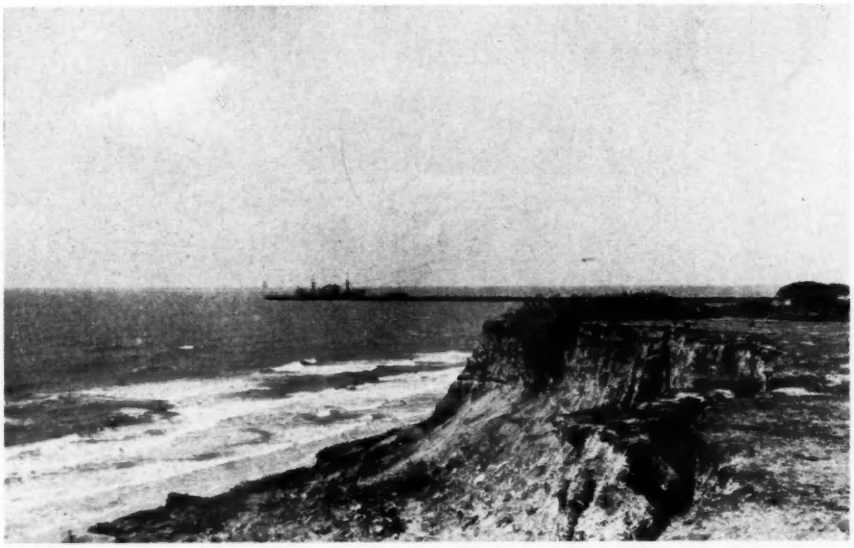

FIG. 7. Wave-cut cliff and Standard Fruit and Steamship Co. pier at Puerto Cabezas.

Honduras and Panama, but conditions on the Miskito Coast do not lend themselves to this sort of operation. In Nicaragua independent buyers still obtain native-grown fruit along the Río Coco, the Río Escondido, and the Río San Juan, and small bi-weekly shipments are made in refrigerated ships to Tampa, Florida. But this is a far cry from earlier days when bananas were the economic mainstay of the coast. They reached their peak production in Nicaragua in 1929 when exports exceeded four million stems and accounted for 27 per cent of all Nicaraguan exports by value. In the same year Honduras exported 29.8 million stems, a figure which had dropped

[45] Between 1896–1904 the Emery interests established nurseries and planted mahogany along roads and in openings on the Río Grande according to the requirements of Nicaraguan law rather than pay off inspectors as was the usual custom. In 1928 these plantings were cut over again with several hundred trees reaching diameters of 14 to 22 inches. F. Bruce Lamb, "The Status of Forestry in Tropical America," *Journal of Forestry*, XLVI (1948) : 721–26.

to 12.7 million stems by 1950–51. Honduras production today is confined to the fertile recent alluvial soils of the north coast (Trujillo to Puerto Cortez) where major flood reclamation operations can be used to cleanse the land of Panama disease fusarium and, at the same time, to deposit a thick layer of neutral silt.

CASTILLA RUBBER AND TUNU

Rubber, too, was at one time an important export from the Nicaragua portion of the Miskito Coast. The Castilla rubber tree is an important element of the mixed rain forest behind the "bush line" and the rivers draining eastward to the Caribbean through the savannas provided highways of commerce for the native

FIG. 8. Cut-over pine land along "Nipco" logging road between Puerto Cabezas and Waspam. Note excellent regeneration in foreground as result of protection from fire for two years.

caucho tappers. The earliest center of activity seems to have been the Río San Juan valley, shipments from San Juan del Norte (Greytown) beginning in 1860 and reaching 700,000 pounds by 1871. The rubber boom had burst, however, by the end of the century in the face of over-bleeding and competition from Hevea-type products from the Amazon and from the new plantations of Southeast Asia. An export duty of ten cents a pound had not helped, and the flush of enthusiasm for the banana business and the rush to the new gold mining districts drained off much of the limited labor supply.

World War II once more brought an enthusiasm for rubber as the U.S. Gov-

ernment, through the Rubber Development Corporation, pumped millions of dollars into the Caribbean coast of Nicaragua (and much smaller amounts into Honduras) in an effort to stimulate production. Labor was always short, partly because the gold mines continued in operation, and costs were excessive, but, by the end of April, 1945, Nicaragua's east coast had produced 3,374 long tons of rubber for the U. S. Government.[46] Over 40 commissaries had been established on the Coast to supply 5,000 Indian and Creole tappers and a salaried staff of 165 persons. Thirteen landing strips for small aircraft had been constructed, chiefly in the area between the Río Grande and the Río Coco, and thousands of miles of access trails were opened. Many of the airstrips could be built quickly and cheaply on the edge of the savanna, as at Waspam, Bilwaskarma, Awastigny, Alamicambra, Brewer's Lagoon, and Caratasca, but those cut out of the monte have long since been overgrown except where found to be adaptable to mining company requirements.

Among the adulterants (always a problem to the R. D. C.) one of particular interest frequently found in rubber coming out of the upper Río Coco area was *tunu* (*tuna*) gum.[47] This latex, likened to balata, was well known to the Miskito and Sumu Indians of the upper Río Coco where the thick inner bark of a certain tree, composed of many layers of strong, interlaced fibers had long been used for the making of sleeping mats, blankets, hammocks, and clothing. That tunu was not entirely unknown to the outside world is indicated by reference to "tuno blankets" and "tunna" in the list of exports from the Cape Gracias á Dios custom house in 1909–10, along with rubber, deer and cattle skins, mahogany logs, and gold.[48] It remained for an American trader at Waspam to develop a legitimate export market for tunu gum, which for the last five years has been shipped by air, via Managua, to Chicago chewing gum manufacturers. The black blocks of tunu are brought down the Río Coco in dugout canoes to Waspam where they are cut up, boiled in water, and washed in a stream until the gum is white and clean, whence it goes by plane to the U. S. The tunu tree apparently occurs in commercial quantities almost exclusively in the upper Río Coco drainage, San Carlos being the principal collecting place for gum gathered on either side of the river. Some 2,000 persons are said to be currently engaged in the industry.

Botanical identification of the tree from which it comes seems not to have been made with certainty, but from descriptions it is probably *Poulsenia armata,* a medium to large lactiferous tree with armed (prickly) twigs and a buttressed trunk which occurs sparingly throughout much of tropical America.[49] The apparent

[46] The record of the war-time rubber effort in Nicaragua is contained in the Rubber Development Corporation papers, Sets 1 and 2, Nicaragua, in the National Archives, Washington, D. C.

[47] Rubber Development Corporation, Set 1, Nicaragua, No. 35a (1942), National Archives, Washington, D. C. Nicaragua's rubber production was the highest of any Central American country under the R. D. C. program.

[48] Cape Gracias á Dios Post Despatches, Invoice Book 1908–10, National Archives, Washington, D. C.

[49] Samuel J. Record and Robert W. Hess, *Timbers of the New World.* New Haven, 1943. p. 394.

localization of production to the San Carlos area, from which exports of 700,000 pounds were reported in 1952, may relate to Indian interest in the tree. The tree is reported to occur gregariously, apparently as an aggressive, secondary forest element in old fields, hurricane blow-down areas, and on savanna margins. Its caustic seeds are said not to be touched by the peccary (*wari*) as are those of the Castilla and so are less widely distributed.

With good cutters taking 10 to 12 pounds of latex a day (worth the equivalent of perhaps 10 cents a pound U. S. money), pressure on the tunu resource is heavy. Trees are tapped two times a year, with tapping being conducted for all except one or two months at the end of the dry season. The sap is coagulated with lye or with the use of a jungle vine much as is the milky fluid from the Castilla rubber tree.

* * * *

An English- and Miskito-speaking Protestant enclave within a Spanish-speaking Catholic world, the Miskito Coast of Nicaragua and Honduras with its 80,000 inhabitants has been until very recently a land of mystery for which Managua and Tegucigalpa have had little understanding or concern. Until the establishment of regular airline service from Managua to Bluefields, Puerto Cabezas, and the gold camps, it was easier to get to the Miskito Shore from New Orleans than from the interior capitals, but now that is all changed, at least for the country south of the Río Coco. The opening of the often-delayed truck road from Managua to Rama may likewise stimulate further economic development and settlement by Spanish-speaking peoples, especially along the Río Escondido. But economic prospects are at best modest. The United Fruit Company's 1,400 acres of African oil palm and 2,500 acres of mahogany, cedar, and teak plantations on abandoned banana lands along the Río Escondido represent the first serious attempts at tree-farming in this tropical high-rainfall area where tree crops may provide one of the few possibilities for a really permanent agriculture. Perhaps, too, the planting of introduced pasture grasses on forest soils behind the "bush line" may one day be dove-tailed with a beef cattle industry on the savannas. A better knowledge of tropical soils, their potentialities and limitations, is obviously necessary. The understanding of the causes underlying the presence here of an extensive pine savanna, for which a tentative theory has been suggested above, would be an important step in this direction.

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VALUES AND CONCEPTS IN CONSERVATION*

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GEOGRAPHERS in the United States seem to have committed their profession to a shepherding of natural resources. It is fitting that students of the earth's surface should keep tab on its riches, take part in planning its management, and apprise the coming generation of its potentialities. Depletion has so shockingly marked the history of American resources that its opposite—conservation—has been adopted as the keynote, if not the definition, of both public and private[1] programs for using our resources *wisely*.[2] Wisdom here involves effective judgment as to satisfaction of total wants. It seems proper to inquire into these wants as they affect our decisions and into the bases of our judgment in determining whether it is depletion or conservation we really wish.

This paper will be limited to a consideration of the ideological foundations of natural resource conservation as a means to future material welfare. The social and spiritual values that may depend on material welfare are beyond its scope.

Any plan for the future requires construction of some idea of future conditions and an appraisal of alternative programs in the currency of a social or individual value system. Basic to the appraisal of a future plan is the establishment of a rate of exchange whereby a future value may be measured in present terms. Questions involving the conservation of natural resources hinge on the concepts and values of the future. Both are elements of culture; the values always, and the concepts often, lack objective foundations which are free from the thought patterns of a particular society. Like other phases of resource utilization, optimum time distribution of use varies from one society to another.

BASIC VALUES AND IDEAS

Limitations on the Future of Primitive Man

Distant future may be non-existent to primitive man, whose thought begins with the tangible and finds trouble enough in what can be seen, but not understood. Even his past enjoys an existence that the future cannot. A recent analyst of man's changing outlook[3] suggests that the fixity and stability of primitive society lead to an emphasis on the past; this emphasis in turn reinforces the stability. With a

* I wish to acknowledge the helpful suggestions of Homer Aschmann, who read and re-read the manuscript during its preparation.

[1] The anomaly of big business in the thick of the fight on the side of conservation is discussed by Erich W. Zimmerman, *World Resources and Industries*. New York, 1951. pp. 801, 804.

[2] Harold Innis ("The Economics of Conservation," *Geographical Review*, XXVIII (1938): 137) has questioned the lack of philosophy in American conservation literature. Specifically, "the whole question of conservation is begged by its definition as 'wise use.'"

[3] Roderick Seidenberg, *Posthistoric Man*. Chapel Hill, N. C., 1950. pp. 75–76.

more conscious mode of existence man's intellect (replacing instinct) begins to comprehend the future by extrapolating the process by which the present has been steadily transformed into the past. A working concept of the future is developed. Seidenberg suggests that only the dead had a future in Ancient Egypt and Medieval Christianity, whereas later generations show an "increasing concern with the yet unborn" and a growing curiosity about the collective future.

A people without a future has no reason to conserve. Such a society might survive either through inability to destroy its resources or through instinctual practices which actually effect the necessary protection. When change is not conceived, it may not occur; witness the introduction to the Americans' time scale of the Rio Grande Valley Indians who felt it foolhardy to move people into an irrigated area which would last only a few hundred years before its reservoir silted up. It is doubted that *Homo sapiens* has ever been totally without a future. The storage of food for tomorrow's meal is probably characteristic of the most primitive man. The preservation of fire or the materials for making it must have involved specific planning, and any tool or weapon fashioned for specialized use is predicated on a future. Consciousness of the more distant future may have been slow to emerge. Even so retrospective a pattern as ancestor worship, however, may have strong implications for the future in that it assumes descendants to carry on the proper reverence for the past.

The Expanding Future of Industrial Man

At the other end of human time, is man's interest in the future yet increasing? The greater predictability envisioned by Darwin[4] might help to satisfy man's curiosity and to solidify his concept. As the future and the effect of conserving action become more certain, any purpose of conservation becomes the clearer. The planting of a fruit tree and the building of a factory are acts which are often explainable only on the basis of the interest of a later generation. The increase of life expectancy itself has definite implications for conservation, but the main concern here will be the more distant future of subsequent generations.

Predictability has actually been high in ages when progress was non-existent and in totalitarian states that exerted an actual control. The predictability we enjoy through increased understanding may be more than offset by the pace of change now occurring. Man's very ability to comprehend has contributed to change no less than to his ability to foresee the change. An assurance of ultimate predictability seems to rest on the assumption of a finiteness of nature for man to circumscribe.[5] Seidenberg's[6] assumption of predictability involves increasing *ex ante* control. Man's interest in the future may yet increase while his knowledge of the intermediate future (the predictability of his own state at a given time before the hypothetical perimeters are approached) does not increase.

[4] Charles Galton Darwin, *The Next Million Years.* Garden City, N. Y., 1953. p. 55.
[5] Seidenberg, *op. cit.*, p. 68, "perimeters of the future." Darwin, *op. cit.*, pp. 27–28.
[6] *Op. cit.*, pp. 89–90.

Margaret Mead suggests that the "emerging American character"[7] is oriented more to the present than was the American character of a decade ago. She attributes this short-term change to the uncertainty of the future in a world in which America is threatened by oustide dangers. The quickening of economic pace not merely to meet these dangers, but also to raise the present level of living (largely through increased employment), results in a more rapid use of resources. Concern for the future may underlie the change, but, with a high uncertainty, economic provision for the future is relatively futile.

Self-Identification with People of the Future

Given an image of the future in which men like ourselves will inhabit the earth indefinitely, what is our relation to them? The influence that governs any deliberate action we may take with respect to them[8] is the degree of our sympathy toward them or identification of ourselves with them as fellow human beings. A maximization of our present satisfaction demands assurance of their satisfaction also. A long discussion of the nature of our identification with people of the future is beyond the scope of this paper. It may involve the whole concept of immortality whether one conceives himself as living in the future through his natural or cultural descendants or as a surviving consciousness. Socrates's rule that one should behave as if his soul was eternal might even be extended to treatment of material things.

Sympathy for others varies among individuals, but must be a well-nigh universal trait, essential as it is for the survival of a social animal such as man. It is translated into resource utilization plans by individuals and by groups with the aid of such institutions as governments and religion.

If we assume responsibility for resources, toward what future people are we to direct our sympathies? And what is the material expression of sympathy for a person of the future? Is every mortal soul an act of God and therefore entitled to our attention? If so, sympathy may demand equality of wealth or of opportunity for all peoples. This idea is embodied in religions and in political philosophies professed by millions of people. It is logically extended into the future in the same terms. The obligation to others may call only for some minimum standard conceived as the necessities of life or of living; this specification could likewise be extended to future populations. Or should we now assume that people are brought into the world at Man's discretion and that each is responsible only for his own line?

An individual identifies himself with different organized and unorganized groups. Within a group, relevant to a particular purpose, mutual responsibility is recognized; outside the group it may be denied. The aspirations for the future may involve only one's own group; indeed the individual's hopes may sometimes embrace an institution rather than the people who form it. Concern for another group de-

[7] Wm. Snyder lecture, Los Angeles City College, April 20, 1953.

[8] So long as we assume that the future itself cannot affect us. If our spirits can be disturbed by action of our descendants or if an avenging deity can act in their interest, selfish motives may induce us to consider them. Prospect of reincarnation provides material interest in the future.

creases with increase of its remoteness and of the ignorance regarding it, with increasing difference in habit and lack of common interest.

A rough parallel is suggested between spatial or social remoteness and temporal remoteness. The remote group has an unreality which is similar to that of the future. Much of the aid to remote parts of the world today, however, involves an element of material self-interest which the remote future cannot offer us. A material evaluation of the future must be fashioned entirely on a non-material level.

The tenets of some religious sects may lead man to abandon responsibility for his resources to God, but such neglect is likely to occur where end results of particular actions are not evident. The future may qualify here. The philosophy that God will take care of men as He wishes logically leads to no conscious conservation at all. The conditions under which He made manna available to the children of Israel suggest that conservation is no business of men, that it may be a social form of miserliness.

The Population of the Future

Questions of resources and of population are plainly inseparable; each is a function of the other. The values with regard to population become even more involved than those with regard to resources. It is my intent to examine primarily the resources, considering solutions for differing population conditions, but with little evaluation of population itself.

The populations of the future may be controlled collectively or individually; they may grow or shrink in a manner beyond human control. The prevailing ideas of the population of the future, among whom the resources must somehow be divided, fall into three groups: 1) the Malthusian population, living at a meagre subsistence level, always saturating the available food resources; 2) a population controlled by the will of man, maintained at a comfortable level; and 3) a freely growing population, comfortable because outstripped by a growing availability of resources. As between the first and second, if the two co-exist in different societies, the first tends to win out in the long run as the greater numbers of the more fertile group surpass and ultimately displace the others. Expansion of French at the expense of the English in portions of modern Canada has occurred through the action of many individuals; encouragement of population increase by dictatorial governments has aimed partly at gaining a similar advantage. Hope that the third condition will be fulfilled obviates any problem that growing populations might entail.

If quantity of future population is important, material resources are also important under all three assumptions. If, however, size of population is entirely subordinate to material living standards, material resources may be worthy of consideration under none of the assumptions. If a future society is deemed optimum only if it surpasses minimum standards of resource-man ratio *and* number of people, it is only under the second assumption that material resources, and therefore their conservation, are worthy of concern.

Conventional Concepts of Resources

Resources are commonly defined in terms of usefulness in fulfilling human wants. The concept is highly dynamic in involving all the changing patterns of want and technology in relation to all nature.[9] Wise use of resources is no more than fulfillment of this definition.

The resources of primitive peoples are relatively fixed and unchanging, especially if territorial boundaries are established. Opportunities for expansion are rare. Totemism and taboo may place some irrational limits on use of raw materials, but general concepts of resources probably depend on tangible experience. The resource base must seem painfully finite unless faith is placed in Providence. Many gathering tribes are reported to collect from different portions of their territories in systematic rotation[10]; some shifting cultivators rotate their crop land on a short-term basis.[11] These practices suggest a recognized pinch of resources. (Some primitive peoples have deliberately undertaken to prevent population increase, while others have refused to be concerned with it. Efforts at control of population and resources would be futile for groups who could not keep others from moving into their territories.)

A pattern of resource expansion, either technical or territorial, may stimulate the imagination to theories of indefinite increase. Concepts of either expansion or of ultimate perimeters depend more and more on abstract ideas. Since the future presents many unknowns on both sides of the man-nature complex, current concepts of the future shape of resources are highly divergent.

Natural resources should be viewed as a whole and in terms of their total effect. Some resources are interchangeable in use; others stimulate one another in use. The fertility of a certain cotton field may be maintained by the use and depletion of phosphate mineral deposits. Its soil may be preserved from erosion by consuming petroleum in tractors used to build diversion terraces. When the petroleum is gone, liquid fuels may be prepared from the more plentiful coal. The coal may also be used as a raw material in the production of a fibre that competes with cotton. An alternative use for the cotton field may involve food production on a completely self-sustaining basis. Neither phosphate nor petroleum nor coal nor soil may be isolated as a separate problem. Even if certain important functions are dependent on single resources, we must nevertheless choose among all resources in allocating the limited effort which is available for exploiting them.[12]

Most resources are now conceived as either renewable or non-renewable. These concepts are relative to human time; both break down on a geologic or astronomic time scale. Renewable resources can be managed to provide an annual production

[9] See Zimmerman, *op. cit.*, pp. 3–17.

[10] *E.g.*, the Paiutes in C. Darryl Forde, *Habitat, Economy, and Society.* N. Y., 1949. pp. 35–39.

[11] O. H. K. Spate, "Changing Native Agriculture in New Guinea," *Geographical Review,* XLIII (1953): 170.

[12] C. H. Hammar, "Society and Conservation," *Journal of Farm Economics,* XXIV (1942): 109–110.

or *flow* for an indefinitely long period. Non-renewable resources are the finite *stocks* of minerals which, once used and dispersed, are henceforth unavailable. Under certain conditions of use of certain resources the human and geologic time scales overlap, producing borderline cases between flow and stock resources. Certain ground water deposits can be quickly consumed by rapid pumping for irrigation, but would be flow resources if pumped for household and livestock. The standing timber in a forest represents a stock which can be consumed, but the rate of growth ultimately limits the production.

The organic resources which alone provide man's basic necessity—food—are inherently flow resources. The mineral resources include our chief present sources of energy and a major portion of our structural materials. The use of mineral resources has been expanded particularly rapidly in the industrial age. A great portion of their uses might be classed as non-essential. Except for such resources as water, water power, and air, the minerals are exhaustible. It seems fortunate that our vital needs are met by flow resources. Nevertheless many flow resources can be destroyed, and attention to their protection seems necessary. Some important stock resources may be replaceable by flow resources in the future, others by extremely plentiful stock resources. The possible use of direct solar energy in large quantities illustrates the former; an example of the latter is possible production of the abundant element aluminum from a much greater variety of rock and regolith than the scarce bauxite used now. In a complex society, however, the stock resources may become needed tools in the exploitation of flow resources. Thus food may depend on stock resources too.

What Limits Resources?

It is patently impossible in our present state of knowledge to fathom the ultimate availability of energy, structural materials, and foods. Conflicting ideas stem from emphasizing differing portions of our experience and from differing applications of logic to develop concepts of the ultimate. The concept of stock resources suggests that certain materials will soon be exhausted. The extrapolation of the events of the last two or three centuries suggests the happy solution that technology will develop new uses and new materials faster than we consume the stocks. Recovery of certain minerals from the sea, use of lower grade deposits, continued increase of proven petroleum reserves even in the United States, development of common materials to replace scarcer ones, and the hope of solar energy to replace stored energy —all these suggest the trend. Led on by such promises, we can well consider our resources as infinite,[13] superior even to the bounty of an ever-providing God. Faith is placed in human ingenuity and to man belongs the responsibility of discovering, but not of saving. Is such a faith a new human instinct in an age of intelligence, a promise of a *deus ex machina* for every impasse, eagerly accepted by an audience carried away by its own enjoyment of plenty?

[13] Eugene Holman, "Our Inexhaustible Resources," *Atlantic Monthly*, CLXXXIX, no. 6 (June, 1952) : 29–32.

The rationale of this idea of infinite resources rests on the assumption that the utilization of resources under certain conditions stimulates techniques which make more resources available in the future. In other words present and future resource use are complementary.[14] Certainly such a relation has not existed for all societies nor indefinitely for individual resources. Britain's shortage of most raw materials during most of the last hundred years and the increasing dependence of the United States on imports of raw materials are evidences that even these clever peoples find their resources finite. If the resources of any one country are finite, it seems safe to believe that the resources of the world are finite. Though technological expansion may, among other things, be a function of size of population and size of the earth, it is doubted that any combination of both surpasses a critical point beyond which everything is possible. The idea of indefinitely continuing progress may, however, have validity within certain broad limits.

One may accept the concept of expanding resources in its theoretical state based on current patterns of technological advance and economic utility, yet wonder whether society can sustain the march into greater complexity. Faced with diminishing returns from our investments, we may find the incentives inadequate. Faced with more capital outlay per unit of output, we may find that the risk mounts too rapidly. Faced with ever more intricate social organization, we may be unable to keep it running smoothly. Physical materials are not resources if societies cannot organize themselves to exploit them.

Another concept of infinitude of resources is based on the laws of conservation of matter and energy.[15] Both are indestructible and hence may theoretically be used any number of times, though it is recognized that they may become unavailable. Thermodynamics indicates, however, that unavailability (chaos) is an ultimate tendency. Energy, once used, passes to a lower state; the levelling of all energy would leave none available for any organized purpose. The utilization of specialized materials results in their dispersal, whereas we have been able to exploit materials only when they are relatively concentrated. The ultimate of unavailability is a perfectly uniform mixture of all substances in a uniform energy state. No material would be concentrated, nor would energy be available to concentrate it.

Perhaps it is this last condition that suggested the equivalence of energy to all other resources[16] (as it is now known to be equivalent to matter itself). Given the energy and a machine to do the job, any material could be separated from all other

[14] Complementarity between two quantities requires that, if one is an independent variable and the other is dependent, the dependent variable will increase or decrease when the independent variable increases or decreases respectively. The opposite of complementarity is competitiveness, which requires that the change in one should be opposite to the change in the other. In the long run a true stock resource must illustrate competitiveness between present and future use; each pound can be used at any time, but only once. Holman's concept, relative to resources as a whole, involves a perpetually expanding economy, each period build on the preceding.

[15] Hammar, *op. cit.*, p. 112.

[16] *Ibid.*, p. 120.

materials even in the most chaotic state. Chemical reactions among the elements or compounds isolated could produce any recombination desired. Doubtful assumptions appear even in the theoretical state of this concept. When man acquires the ultimate knowledge of which he is capable, does it follow that he can prepare mechanisms for all conceivable transformations and transmutations on the additional condition that he can make up the energy deficits involved?

And what of the organic resources? Whatever special order organic resources represent is destroyed in their consumption. Organic evolution seems to represent a specialized reversal of the greater tendency toward chaos.[17] Within our experience organisms have sprung only from other organisms. What assumptions may lead us to believe that energy is the necessary and sufficient condition for their duplication?

OBJECTIVES OF CONSERVATION POLICY

Conditions for Considering Conservation

The faiths and beliefs of the population will determine what goals societies attempt to achieve through conservation. Even though we conceive the dimensions and basic values of the future to be those of the present, and even though the population of the future be within man's control, we encounter unknowns in trying to predict resource discoveries and developments. We must either recognize uncertainty or build some arbitrary concept. As already demonstrated, certain premises lead to the conclusion that conservation is not necessary. If present and future use are complementary, the resources problem is, of course, how to use them faster. Conservation may be a matter of interest only if present use sometimes competes with future use. The acceptance of one or the other of these basic principles—competitiveness or complementarity—for the long run is a matter of faith. My considerations of conservation are necessarily based on the assumption that present use competes with future use. This is not to deny that each condition does exist for particular resources.[18]

Even Use over All Time

A philosophy of equality of opportunity for all generations regardless of time demands that resources be kept in a state not below their natural level. If we assume an indefinite time span for *Homo sapiens,* stock resources could be used only at their geologic rate of accretion or destruction—in other words, practically not at all. More rapid use is impossible in the long run anyway. It might, however, be possible to use some metals in non-expendable tools and machines. Flow resources could never be allowed to fall below the level of maximum net productivity. The even more exacting condition that all individuals are entitled to equal portions of the earth's material goods could never be attempted unless all the future were

[17] Seidenberg, *op. cit.,* pp. 148–150.

[18] Hammar, *op. cit.,* pp. 115–116, 119, recognizes both relationships and suggests differing "restrictive" and "expansive" policies for handling the respective resources.

known. Consumption of goods would have to be greatest in periods of greatest population. Such a plan might be impossible in the case of perishables in any event.

Preference for Present

Few people today accept the idea of leaving great blocks of our resources untouched.[19] These resources are recognized only in terms of use, and conservation programs are tools to facilitate maximization of some function of this use.

A resource plan must be made in the present. Most individuals and societies give some preference to the present, if for no other reason, because they do not have to bargain with the people of future generations. For that matter many individuals also give preference to the present within their own lives in spending their money or borrowing when they do not have it (though we must realize that a person who borrows when he is young to repay when he is older is not expressing a pure time preference; as repayer he does not plan to be in the same circumstances as he was when borrower).

Preference for the present may be justified as an uncertainty allowance even though we hold the basic philosophy that the future and its people are precisely as important as the present. The uncertainties of the future include the possibilities that new resources may replace those we save (obsolescence), that populations may be smaller, and that catastrophe or evolution may bring an end to *Homo sapiens*. These unknowns are the more likely the longer the time. The possibility that future generations would not need resources as we do can be introduced through a time discount which would allow each successive generation a smaller share of what appears to be available. If the time discount equals the rate of increase of per capita productivity, we might hope to balance depletion with technological advance. The time discount rate could, of course, be negative to allow for the possibility of greater need in the future. Since the one certainty is present usefulness of resources, such rationally determined time discounts would normally favor the present. Once the time discount rate is established, the share of each generation in known stock resources may be apportioned according to a formula described below. Some shifts of flow resource use toward the present may also be indicated.

Prevention of Waste

In opposition to the Puritan view of saving for the virtue of saving,[20] a significant philosophy in the United States today holds that we should enjoy our resources

[19] The idea is usually dismissed merely on the basis that it is ridiculous. Ridiculous it is in terms of the very fact of our present usage of resources. The idea is nevertheless the result of logical application of assumptions that may be as likely as their opposites and of values that many people maintain. The refusal of the Old Order Amish to use mechanical power on their farms may be partly supported by fear of destroying resources; in contrast their use of soil is considered excellent. Correlative with dismissing the idea of leaving resources untouched is the sense of having to maintain the cultural capital we have accumulated in the process of using them.

[20] J. K. Galbraith, "The Unseemly Economics of Opulence," *Harper's Magazine*, CCIV, no. 1220 (Jan., 1952) : 58.

as intensely as we can. The limit on rate of use set by this philosophy is simply the rate at which we can use. A condition often attached is the limitation of conservation effort to prevention of waste. Waste presumably means some form of exhaustion without use. The concept waste must be defined economically since many forms of waste do not involve wanton carelessness. In the case of petroleum it seems obvious waste to blow by-product natural gas to the air. The abandonment of recoverable oil in the formation because of overly rapid production is less obvious, but may be equally costly. Is the production of carbon black from natural gas waste? Or the burning of oil or gas under a steam boiler when the more plentiful coal would be only slightly more expensive? Does each stock resource have a highest value, use for other purpose than which constitutes waste? If so, who is the waster, the boiler operator or the union responsible for the high cost of coal? Is it waste to spill a little overflow gasoline on the ground to save valuable time in filling an automobile's tank? Visitors in this country are amazed at the frequency of such occurrences. Waste must be defined in relation to the aim of the particular system of values. A philosophy of prevention of waste must be identical with some philosophy of use.

Protection of Potential Resources

Another important end of conservation depends on unrecognized values of known substances. Many of our present resources were not considered valuable in times past. So long as the present trend continues, new resources will continue to be created out of today's *neutral stuff*.[21] The extinction of unused plant and animal species and varieties may show disregard for the future.[22] The purposive preservation of this diversity of biota against the possibility of new demands and new techniques is necessarily a social matter. It is impossible to set other than arbitrary standards for determining expenditures to this end and for guessing at the benefits to be derived in the future. Any physically irreversible process involves potential loss even though no presently usable value is involved.

Triumph of Depletion

The diversity of peoples and societies embraces a wide range of attitudes and abilities in regard to the utilization of resources. The crucial decisions with regard to resource utilization are likely to be made by those who favor depletion. The conservatives necessarily lose out for several reasons. Those who favor depletion are more aggressive in obtaining control of resources, for depletion yields higher immediate profits than conservation. Depletion is often irreversible, whereas conservation is *sua natura* reversible. The nations depleting resources (their own and others') have used them partly to build military power which further insures their control. Economic emulation and military competition have forced other individuals and

[21] This term has been applied to resource theory by Zimmerman, *op. cit.*, p. 8.

[22] Carl O. Sauer, "Theme of Plant and Animal Destruction in Economic History," *Journal of Farm Economics*, XX (1938) : 770.

nations, respectively, to develop their own resources in similar fashion. Certain fugitive[23] resources especially promote competition for their capture.

The depleters then control the earth; it was previously suggested that the prolific will control the earth. We can hardly know whether we are now in transition from the first condition to the second. That the two groups are largely different at the present, however, may be only coincidental.

Hope for Conservation

Conservation, however, may be a process which tends toward self-justification and self-acceleration. If a conservation measure should make some future condition more certain, then other conservation measures would be safer and more plausible. The reduction of uncertainty increases future values for either public or private planners. It not only reduces the risk involved in the investment, but also increases the likelihood that the benefits can be enjoyed to the utmost.

The most valuable resource is probably worthless without other resources with which it is used. The simultaneous planning of all resources in a great integrated scheme may justify measures which alone would not be worth the effort. A measure which assures the future of one resource may enable a private concern to carry out another measure which will increase future availability of another resource. The process may build up, step by step, with plan after plan falling into place in a generally more certain future.

Conservation always increases some future availability at the expense of current investment, though it need not curtail present use of the same material.[24] Even conservation by curtailment of present use, however, may start a chain reaction if the shortage of one material reduces the demand for others.

Group Effect on Resources

History shows that some societies have been particularly effective in conserving their resources, while others have been as notable for their failures. It would be of interest to know which successes and which failures were incidental by-products of some general cultural conditions and which were direct results of conscious values and ideas of the group or its individuals. A small hunting and gathering tribe carefully working its territory seems to require a group spirit or control if the resources are to be preserved; such resources, fugitive with respect to individual interest, might easily succumb to the pressure of people working on a narrow margin. Soil destruction in the Mediterranean region and the European overseas settlements[25] has been effected by peoples who, at least temporarily, could expand their resources. Protection of European soils during one of these expansions has been effected by rooted individuals who did not identify their own opportunities with

[23] Resources which are not effectively owned until exploited: e.g., petroleum when the pool underlies several properties; fish in oceans, lakes, and rivers; uncontrolled public grazing lands.

[24] For a technical definition of conservation, see S. V. Ciriacy-Wantrup, *Resource Conservation.* Berkeley, Calif., 1952. pp. 51–53, 379–380.

[25] Sauer, *op. cit.*, pp. 766–767.

the expansion. Yet inability to expand resources to keep pace with population growth must lead to depletion. The unstable combination of a growing population and fading resources can result only in tragedy.[26] The impact of European entry on natives of other continents has often upset the behavior patterns which kept their resources in equilibrium; the appearance of traders in Africa resulted in sad depletion of the particular resources which the natives gathered in exchange for trinkets.[27]

Present Aims

We may reasonably state Occidental society's present conservation philosophy in the following approximate terms: Resources should be enjoyed to the utmost; we should often protect flow resources from irreversible reduction in flow; we should make a reasonable effort to keep stock resources from becoming unavailable in the future, but not at the expense of depriving large numbers of people of their use; we are hopeful that technology will so broaden our resource base that we will not have to worry about depletion of our present resources; generally we prefer enjoying our luxuries while they last to sharing them with our descendants.

As has always been the case, man does not know what lies ahead of him. Can such ignorance justify a failure to plan on the basis of what is known, while relying on what is unknown?

Limits of Present Vision

In this state of ignorance how far ahead is man interested in looking? Few can worry seriously about matters that will run beyond their children's lives. We have a few thousand years of recorded history, but this period has been characterized by complementarity of the past and present in resource use. Hitler thought to excite his subjects by referring to events that would assure Germany's future for a thousand years. Certainly a hundred thousand would have seemed a ridiculous figure. Were Germans really concerned about a time so remote as a thousand years? (It is hard to believe that Americans could be.) Perhaps man, in his dreamier moments, may actually be motivated by such prospect.

CONSERVATION AND PRESENT ECONOMIC SYSTEMS

Laissez Faire and Conservation

Although natural resources are material and hence quite properly handled by the standards of the economic system, it is doubtful that our laissez faire structure based on money and credit was designed to meet society's need for conservation. Means of exchange are based largely on present needs, and systems of credit usually involve times no longer than the human life span. Long-lived institutions such as governments and corporations may prolong this period in some cases, but none have life expectancies comparable with mankind's. Our most familiar capital goods

[26] This specter particularly was developed by William Vogt in *Road to Survival*. New York, 1948.

[27] Jean Brunhes, *Human Geography*. Chicago and New York, 1920. pp. 338–339.

such as buildings, roads, and machinery wear out and are renewed with surprising rapidity. Are our accountants instructed to write off our natural resources in the same business-like fashion? To the extent that men accept the system and use it, we must agree that our conservation values are expressed in its terms. However, it probably acts at times in a manner counter to society's direct conservation goals, and group action is taken accordingly. Fortunately the system does provide means whereby the future can often assert its own values. It is also good public policy to try to make the desired type of resource use economic; this condition effected, the program requires little administration.

The Importance of the Interest Rate

The economic link in any plan that involves a span of time is the interest rate. It must be used in computing cost of investment and in discounting deferred income. It is the means of comparing a value at one time with a value at another. Many rigidities and variations in risk keep interest rates from equalizing at any time. Generally, in a free economy, the interest rate is a function of the supply of and demand for money, measuring the (marginal) return to the investor of money or goods; it largely controls the rate of penalty for assets now rather than in the future.[28] Government manipulation may make money available at considerably different rates, thus upsetting the function of the rate as a yardstick whereby society tends to use scarce savings to best advantage.[29] (Any investment that returns more than the input, however, can be conceived as a benefit to society; accumulation of even very poor investments can account for vast material progress.)

Any value to be gained in the future can be reduced to a present equivalent by discounting at the interest rate a number of times equal to the time units separating the future from the present. Investment of the present value now in any of a selection of enterprises would be estimated to be equivalent to the future value at the future time. Thus any properly priced investment is estimated to be equivalent to any other in its growth in value at the going interest rate. The value of any enterprise may be calculated on the basis of the profit it will yield in the future, each return being discounted to the present. In theory the owner-operator of a productive enterprise may operate it to the end of his career and then sell it or may sell it at any earlier date, investing the money in another enterprise; his net return and worth will be the same.

The interest rate is not in itself an expression of time preference. It serves to guide the decision of a person in choosing whether to save or spend. Some would choose to save even if the interest rate were negative (and inflation may make it effectively so); others choose to spend even if the interest rate is very high.

The interest rate is an expression of confidence in the future. The money received from mining a resource (which a high interest rate favors by the rapid reduction of the value of deferred production) can be invested only in something that

[28] Frank H. Knight, "Professor Fisher's Interest Theory: a Case in Point," *Journal of Political Econocy*, XXXIX (1931): 176–212.

[29] S. V. Ciriacy-Wantrup, "Economic Aspects of Land Conservation," *Journal of Farm Economics*, XX (1938): 469–471.

depends on other resources. If resources as a whole seemed to be near exhaustion, the interest rate as well as the prices would be expected to rise markedly.[30] An entire economy cannot expand indefinitely while its resources are shrinking. The recent rise in prices of products of the United States petroleum industry, in which present and future are part of a quasi-self-contained system, is an example. The justification for the present price rises, and therefore higher return on investment, is not higher cost of petroleum on the market, but higher cost of exploration for (scarcer) oil for the future.

On the basis of uncertainties and other criteria society might establish a rational rate of time preference for future planning. It would be coincidental if such time preference equalled the going interest rate. In the short run society's best time preference is probably the going interest rate, encouraging, as it does, the expansion of the economy, but nothing assures the indefinite continuance of this going rate. In the long run society's interest may demand a different time preference for allocation of scarce resources. Within a generation time preference can be determined by current economic conditions, but a plan for allocation between generations involves unknowns. The long run time preference for society is probably lower than present interest rates. What avails it, however, when going rates tend virtually to wipe out values much more than 50 years distant?[31] Current interest rates are such that important long-range objectives may be masked. Can our future be so uncertain that we are not justified in planning a lifetime ahead? The interest rate itself may have some relation to the human life span.[32] Favoring of certain projects such as conservation, which might otherwise be uneconomical, may be a goal of government-determined low interest rates (which may also favor resource-depleting investments). In some cases the greater certainty of benefit from a public project in the interest of all society may justify the lower interest rate which in turn is needed to justify the project. The social time preference rate equals the interest rate only to the extent that we can assume a perpetually expanding total resource base. If we cannot, "The nation's future may not properly be discounted to present worth and private gain."[33]

Society's Interest against the Individual's

Society is necessarily conceived as a permanent entity, while the individual is ephemeral and less likely to take so long a viewpoint when he has to compete with his fellows in the short run. Society's lower time preference leads to a higher state of conservation as its optimum. In certain emergencies, on the other hand, society's time preference may be much higher.

Society's interest may differ from the free play of capitalism in other ways than

[30] Harold Hotelling, "The Economics of Exhaustible Resources," *Journal of Political Economy*, XXXIX (1931) : 145.

[31] Ciriacy-Wantrup, *Resource Conservation*, p. 79; certain public agencies are using up to 60 years for their planning periods, figuring interest as low as 3 percent.

[32] Ciriacy-Wantrup, "Economic Aspects of Land Conservation," pp. 469–470.

[33] Ralph H. Hess, "Conservation and Economic Evolution" in Richard T. Ely *et al.*, *The Foundations of National Prosperity*. New York, 1917. p. 184.

the time preference rate. A private operator's costs and gains may represent only a part of the costs and gains of society as a whole. Many social costs, such as rehabilitation of the workers of exhausted mines, are not borne by the private producer. Society's benefits are normally greater than those of the producer, since society shares in the consumer's benefits also.[34] A given commodity may be used in several ways, some of which are easily replaceable and some of which are not important; other uses may be keys to the use of other resources which would justify very high scarcity values. Yet under free competition the utilization of the resource would proceed just as if these higher values did not exist. Exhaustion of a resource for lower uses today may preclude higher uses in the future. The limitation of resources to higher uses under free competition is effected by rising prices. Higher values far in the future, however, are worth little today. Prices do not rise unless scarcity or exhaustion is imminent, perhaps within 50 years, and only slowly for much of that period.

The sum of the actions of a number of identical, but independent, individual consumers is often different from the action which would result from a collective agreement among the individuals; if the latter may be said to represent a rational social end for the group involved (the social end must ultimately be measured by the consumers rather than by the producers), the former must not be identical with the social end. In our society unit action is usually a resort in emergencies or in cases when the independent individuals obviously hurt themselves in the short run. As an example suppose that a certain perishable (when captured) fugitive flow resource that goes into a consumer good is cheaply available to the point of its own extinction. It is clearly to the interest of any consumer to limit use to the extent of maintaining the flow at an optimum rate. The consumers enjoy using the resource at a greater rate. Few consumers will refrain from use at the greater rate for the individual's abstention will gain little in that he only makes the limited supply available to someone else. If the resource is exploited by a number of producers, only extinction will result unless collective action is taken. (The voluntary unitization of oil pools is a good example in the area of stock resources.) In this situation, as in some others, monopoly makes for conservation, though usually not at the socially most desirable level. A consumer monopoly would also make for conservation with a different distribution of surplus values between producer and consumer.

Optimum rate of present flow for a private operator under competitive conditions is also optimum rate of flow for society[35] (though, of course, a reorganization of the economy which changed the distribution of consumer spending power would change the demand for particular resources and lead to new optimum use rates). This ideal equality of individually and socially determined action is upset by imperfect

[34] Hotelling, *op. cit.*, p. 144; L. C. Gray and Mark Regan, "Needed Points of Development and Reorientation in Land Economic Theory," *Journal of Farm Economics*, XXII (1940): 44.

[35] Ciriacy-Wantrup, *Resource Conservation*, p. 234. Hotelling, *op. cit.*, p. 143, demonstrates the equality of the private and social optima over a period of time in exploiting exhaustible resources, assuming free competition and the use of the private interest rate as the social time preference.

markets for assets, uncertainty and conditions that lead to uncertainty, taxes, ignorance, monopoly, interruption of operations, and many other conditions. Ciriacy-Wantrup[36] implies that a major part of society's conservation effort could be spent efficiently in averting the wasteful effects of these conditions.

Conservation and Prices

One simple collective action effecting conservation is to raise the price to the consumer. This conservation occurs automatically when a material approaches exhaustion or otherwise becomes scarce. It is very effective if the end is only to conserve; if applied to consumer goods the effect is to eliminate the poor as consumers; the poor of today make way for the rich of the future. Few modern nations would choose to carry out action with this net result. If society raised the price of a stock resource to what it would be worth if very scarce, it would, in effect, anticipate the approaching exhaustion of the resource by limiting it to its highest uses.

Flow Resources and Free Enterprise

A flow resource normally has some natural rate of availability in its original state. The net return (output minus input) is likely to be a steady optimum at some different level of the standing reserve of the resource. It is characteristic of flow resources that production and return can nearly always be temporarily increased by reducing (mining) the standing reserve. The long run result may be a decline in production which, within certain limits, can be restored at some cost. In other cases the decline may be irreversible or total and final.

Consider a riverine fish population which saturates its food resources in the natural state. Moderate reduction of the population by fishing may allow a more rapid rate of growth of food for human use as pressure on the fish feed is relieved. The maximum sustained catch will be obtained if the population is below its natural state. In any season the catch can be increased by expenditure of more effort; the continued reduction of the population may reduce the reproduction rate and likewise the catch in subsequent years. The stock can be built up only by reducing the catch for a few seasons or by establishment of hatcheries. Complete reduction of the stock in any stream can probably be overcome by the expense of artificial re-stocking. Complete extinction in all streams is final; the same species can never be renewed.

The first aim of the owner-operator of a property producing a flow resource is to provide for his own needs during his lifetime. If he were entirely dependent on the property and on getting the most out of it, he would presumably reap an annual harvest averaging somewhat above the long-run optimum, ending with a badly depleted or irreversibly ruined resource. Suppose, however, the owner-operator had a son to whom he wished to pass on the property; he would have to make a direct evaluation involving another generation, planning to turn the property over to his son in a state that would represent his idea of the proper division between the two generations in this intimate case. Most owners would hope to maintain the prop-

[36] *Resource Conservation*, Part III, pp. 97–219.

erty in its optimum producing state; no time preference would be expressed; the property would be managed for equal production in all years. This process could be extended through all time, though allocation of capital costs needed to meet changing conditions and short-run problems would be varied. The European peasant family is likely to identify itself with the productive land on which it is dependent. Preservation of the land has an object quite apart from any market values involved. The more mobile American is less likely to take such an attitude. But even some of the least mobile and neediest American farmers have not succeeded in preserving the soil on their hillside farms in the Appalachians.

In a specialized society interest in one's own children demands interest in the society too. The preservation of a property, however, does not normally require direct interest of the owner in the next generation. The owner can sell his property for its value under normal conditions. His maximum return from the property includes the sale price (which might be borrowed ahead of time) when he finally disposes of it. This sale price is really an assertion of the interest of the next generation in continued production and an expression of its confidence that it can be sold again to another generation. (However, the ability of coming generations to buy depends partly on inheritance. In some primitive societies the coming generation takes over more forcibly.) Through this process a continuity is assured, which tends to preserve flow resources indefinitely. Even a short-run interest in maintaining production from season to season often serves to preserve a flow resource indefinitely. The Nootka transported salmon spawn from other streams when one stream began to run low;[37] their interest probably covered only a few coming seasons, but continuance of the practice would maintain the fishing forever.

When is Depletion Profitable?

The depletion of a flow resource is theoretically profitable when and only when the ratio of the reduction in flow to the year's extra harvest is less than the going interest rate. The mining of such a resource would yield a sum of money which, if invested at the going rate, would give a better return than the resource. Socially, irreversible action is of extremely questionable wisdom. In destroying a flow of present value, it is the present, perhaps, rather than the future, that must be discounted. In the recent past private enterprise has often found sustained-yield operation of forests unprofitable. The annual growth is such a small fraction of the stand that the greater present value of the stand outweighs the prospect of a continuing annual return (the unit cost of production, tax structure, and other matters must be considered here too). The fact that the forest may come back after a long period of time is of value to society, but is not considered by the company that abandons the cut-over land. Abandonment of milpa farms that will not be touched again for generations may be equally final as far as the individuals involved are concerned.

Collective Action in Flow Resources

A society often takes action with regard to resources which is not justified under going time preference rates. The government of the Netherlands has reclaimed

[37] C. Darryl Forde, *op. cit.*, p. 78.

land from the sea at great expense; the government is repaid by the user at an interest rate below that demanded for other investments. Yet society in this crowded land considers the addition of permanently productive land a good investment. Sweden's policy of operating its slow-growing forests on a sustained-yield basis may not maximize present gains, but it satisfies the Swedes that the operation will continue smoothly and that the future of Sweden will therefore be safer. Similarly any centralized economy may act directly on its idea of the public good and bring into use resources other nations would leave idle or readjust the time distribution of resource use in a manner out of line with that produced by the free play of individuals. A paternalistic government in crowded China might find it expedient to use for food production land which lay idle under the former free economy. Even if it would not feed the families that cultivated it, the total food available could be increased.

Protection of Flow Resources

The aims of society and of the individuals who operate most flow resources are not highly divergent. The maintenance of an optimum flow is a common aim, and substantial agreement on what constitutes an optimum flow is usual. Particularly undesirable in most cases is an irreversible reduction or cessation of flow. Against this we have several lines of defense. The last is government action, which may be applied when other methods fail. It may take the form of fiat, tax policy, subsidy, penalty, government operation or some indirect action. Next is collective action by the producers; it is difficult under anti-trust laws in the United States, whereas collective action at the consumer level must nearly always be carried out by pressure on the government. Ahead of this is the interest of the operator, who will protect his property if the yield is high enough in spite of an irresponsible consumer demand for supercritical production. Even if the resource is fugitive in nature so that no individual operator can have an effective vested interest in its perpetuation, the excessive cost of capture in the depleted state may prevent the reduction in flow from becoming total. When a game animal becomes scarce, it may no longer be worth the effort to hunt; a small population may survive which, if later protected, is capable of rebuilding the population. Finally the flow of some resources such as rainfall may not be seriously affected by human action.

Depletion in Emergencies

The institutional and cyclical imperfections in the ideal economy may at times produce a critical period which will be particularly serious when the health or life of the planning agent (human or corporate) is threatened. If such crises can be weathered only by irreversible depletion of the resource, the decision is evident. Averting such crises may be a major goal of social action.[38] On a larger scale the life of the society itself may require irreversible depletion of resources, as during a war or famine; a decision in favor of conserving the resource would destroy, wholly or partially, the end to which the resource was to be put. The proper balance between impairment of resource and impairment of population must be struck in

[38] Ciriacy-Wantrup, *Resource Conservation*, pp. 251–267.

terms of the relative values of the future and the present. Overpopulated areas are chronically in such state of emergency. Subsistence farmers of the Appalachians and at times commercial wheat growers of the Great Plains must sacrifice their resources in order to live.

Checks on Exhaustion of Stock Resources

The optimum use of stock resources may be more widely divergent as between individual evaluation and social evaluation.

If the exploitation and consumption of a stock resource entailed no inertia, the product might be used up in an infinitesimally short time. In actuality the utilization of these resources requires effort (in discovery, in mining, in development of uses and of equipment in which they are utilized). The cumulative annihilation of these resources can increase only as total effort involved accumulates, and this last process requires time. The rate of use of minerals has grown at a rate proportional to itself (complementarity); while the deposits last, mineral use grows like a rolling snowball. Extrapolation of the present curve suggests no satiation point to man's appetite for these materials.

A secondary brake on the rate of use of stock resources lies in the fact that the capital needed for their exploitation will be available only in such quantities as can be justified by the deposits. Assuming a constant demand for the product, a constant cost of production, and a going interest rate, the proper rate of exploitation of a particular deposit can be determined, and its life will be finite; a maximum difference is obtained between initial capital investment (determining rate of production) and present total net operating return (which decreases the longer the production period).[39] The long-run social value of this brake on rate of production cannot be very great. While our economic system usually provides for an indefinite use of flow resources, it helps very little in providing for a long-term distribution of use of stock resources.

Long-Range Outlook for Stock Resources

The early build-up period in the development of a new stock resource is one of temporal complementarity in resource use. If it ultimately leads to depletion, a temporally competitive condition will ensue. Use of uranium and similar fissionable materials for atomic energy and warfare may increase rapidly as new methods of using them develop. They could be used in almost unlimited quantities. Since the supply is limited, however, such a process must sow the seeds of its own end. For some resources we may assume that the relationship of present and future use is complementary in the short run (in which our economic forces operate), but competitive in the long run. This year's use increases next year's, but may decrease that of a hundred or a thousand years hence. The complementary condition hastens the time of competitiveness.

[39] This has been more generally stated by L. C. Gray, "Economic Possibilities of Conservation," *Quarterly Journal of Economics*, XXVII (1913): 505–506; the proper rate of mining has been developed mathematically by Hotelling, *op. cit.*, pp. 140–142.

How can rational societies allocate in time their use of stock resources if they do not subscribe to the theory of indefinite increase of resource use? As already suggested they can use some time discount for uncertainty. The fraction of the estimated recoverable stock resource to be made available in any one interval is equal to the rate by which each successive interval is discounted.[40] Both discount rate and estimated resource would be subject to revision at any time. If neither changes after such a plan is instituted, stock resource use will taper off along the same sort of curve by which it has grown. If this plan lengthens the period of resource use, the time discount rate is equivalent to a lowered interest rate. Sweden's control on the rate of mining her iron ore is a good example of the assertion of a socially, but not economically, determined rate. Sweden's resources appear distinctly limited to a society that identifies itself with that part of the earth. As already demonstrated, if our knowledge becomes total, and the world thereby becomes measured, society should theoretically have no time preference as such; a proper allocation of people and resource use could be made over all time.

Many acts of man make stock resources which would otherwise be available for use in the future either unavailable or much more difficult to recover. The mining of one coal seam may make an overlying seam unavailable as the caving breaks it up into small pockets. These acts are similar to irreversible reduction in flow of certain resources. They bear the same set of relations to private exploiters and to public goals.

CONCLUSION

If nations are independent societies, it may develop that survival is dependent on keeping pace with other nations. Then utilization of stock resources is necessary. This sort of competition between nations would lead to a pattern of resource depletion (or expansion?) similar to that which characterizes utilization within a capitalistic nation even though all nations involved were communistic. The merging of the world into a single totalitarian nation on the other hand could conceivably reduce the exploitation of stock resources.

High taxes, socialization, and communization are said to destroy incentives, leading to lowered standards of living. We may say that taxation, which is essentially involved in all these, is, to the extent of the taxation, an identification of individual interest with that of society. If this incentive theory is correct and if it is indeed society's wish to conserve by deferment of use, then value, means, and end are all accordant in a totalitarian society whose resources are exhaustible. They are likewise accordant in an aggressive capitalistic society whose present and future resources are complementary. The predictability effected by totalitarian control will tend to justify any plan which is made. Economic stagnation too might have the effect of making the most abundant resources exhaustible. Free societies tend to

[40] If the time preference or discount rate is r, the use in the nth future interval will be a fraction of the present use equal to $(1-r)^n$. Since the geometric series $\sum_0^\infty (1-r)^n$, which sums these successive use rates over all time, converges (i.e., has a finite value), finite amounts can be assigned each interval even though the plan covers an infinite length of time.

socialize resources whose use shows markedly competitive relations with future use. Laissez-faire capitalism, when most of the economy is expanding, is not suited to the management of particular resources which are shrinking.

In contrast to simpler primitive societies and totalitarian societies, our society is recognized as one whose values do not "add up." Values in regard to conservation are not exceptional. The soil conservationist and the petroleum conservationist alike exert the same consumer pressures on the exhaustion of both soil and petroleum as do other citizens. It is one thing to look at the land and worry about what is happening to it, another to shop in a competitive market and keep up with the neighbors.

The conflicts that lie behind the perennial arguments about conservation are not merely the result of individual differences and points of view. Even if we ignore residuals from other days, they trace from conflicting threads in the social fabric. Conservation ideas involve abstract values, while the object of the ideas is strictly material. Can ideas really apply? Current experience tells us that material use increases itself, while reason tells us that the world is finite. Many of our personal conflicts span the ideologies of the free and totalitarian worlds. Most of us have a basic totalitarian view of the need for a rational social action combined with a capitalist's enjoyment of material goods. Most of us hold idealistic views of the unity of mankind in all space and time, but are accustomed to acting in our short-run interest and for ourselves or small groups. Prevailing uncertainties thwart man's desire to reason precisely. They even shake the idea of society's eternity. Is it any wonder if at some point in his chain of reason man gives up the attempt and abandons pure rationality for pragmatism? The state of conservation is determined by the interaction of faith, reason, and immediate and ultimate values. The balance of the various conflicts shifts with these variables.

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CHANGING LOCATIONAL PATTERNS IN THE SOVIET PULP AND PAPER INDUSTRY[1]

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INTRODUCTION

DURING the last few years considerable attention has been focussed on industrial developments in the USSR with the greatest interest centering on studies of her resources and heavy industries. This paper is concerned with a study of Soviet paper production, a basic industry the output of which is destined both for ultimate consumer use as well as various industrial and construction purposes. The locational pattern of this industry has changed markedly during the Soviet era, and the specific objective of this study is an analysis of these changing locational patterns.

THE PRODUCTION PATTERN

In comparison with the output of the United States and other leading producers, paper production[2] in the Soviet Union is still on a low level. This is especially true if comparisons are based on output and consumption of paper per capita. Table I shows comparative output data for the leading countries in 1950. As of that date, the USSR ranked sixth in world production, but her per capita consumption of of paper was only a minor fraction of that in the United States and other western nations. Even if the large consumption of paper for advertising and other noncritical purposes in western countries is taken into consideration, the supply of paper in the Soviet Union is highly limited. The lack of emphasis on this industry can only be understood in the perspective of the general Soviet attitude toward the consumer industries. Throughout the Soviet era these industries have been neglected or deemphasized in terms of capital investment, manpower allocations, etc., in favor of heavy industry. Paper production was no exception, even though an important share of its output was not designed for direct consumer use. In view of the rapidly increasing need for this product in the USSR, her limited paper production is of serious import.

THE RAW MATERIAL SUPPLY

Pulpwood

The most important factor in the development of the paper industry in any region is the availability of an adequate supply of pulpwood. In countries like the Soviet

[1] The inherent deficiencies of available data on the locational pattern of Soviet industry must be recognized as a basic limitation on any research on this area. However, this study has proceeded on the assumption that the use of the most recent known detailed data as a base (in this case 1937) in conjunction with more limited later materials makes possible a useful appraisal of the present industrial pattern.

[2] In this study, unless specified otherwise, the term paper includes both paper and cardboard.

TABLE I

WORLD PAPER PRODUCTION*

Country	Production thousands of tons	Production lbs. per capita	Paper Available for Consumption** lbs. per capita
United States	24,294	326	393
Canada	6,813	1,000	268
United Kingdom	2,927	116	135
Western Germany	1,808	73	74
Sweden	1,602	460	189
France	1,490	72	68
USSR***	1,526	15	15
Japan	960	23	23
Finland	938	467	167
Norway	596	369	141
Other	3,137	....	...
World	41,924	....	...

* Source—computed from *Yearbook of Forest Product Statistics,* 1951 (F.A.O. Rome 1951) : various pages. These data show only those countries producing over half of a million tons.

** Production plus imports minus exports.

*** Based on calculations in *Bulletins of Soviet Economic Development,* Bulletin 8, series 2 (May 1953) : 17 modified.

Union whose transportaiton net is still incompletely developed, the accessibility of the pulpwood areas for economic exploitation is also of critical importance. Based on this consideration the USSR possesses about one-fifth of the accessible produc-

TABLE II

ACCESSIBLE-PRODUCTIVE FOREST AREAS OF THE WORLD*

Region	Accessible-Productive Forest Area Millions of Acres	Per Cent of World Total
North America	736	21
Southern and Eastern Asia	405	12
Europe	282	8
USSR	766	22
Latin America	848	24
Africa	356	10
Oceania	59	2
Near East and North Africa	40	1
TOTAL	3,492	100

* *Yearbook of Forest Product Statistics, 1948* (F.A.O., New York, 1948) p. 27.

tive forest area of the world[3] as is indicated by Table II, ranking this region as one of the worlds key forest resource areas.

In terms of pulping species the Soviet Union is in a more advantageous position. Coniferous varieties which are the key raw material sources in the pulp and paper industry predominate in her forest area accounting for approximately three-fourths of the total volume of wood supply with spruce, fir and pine accounting for over half of the total.[4] On the other hand, the larch which comprises a large share of the forest areas does not at present have any significant value as a pulpwood source.[5]

Of equal importance with the amount of pulpwood in any region is the distribution of that supply. Table III indicates the tremendous areal concentration of the forest areas of the USSR.

TABLE III

REGIONAL DISTRIBUTION OF FOREST LAND IN THE USSR*

Region	Per Cent of Stocked Forest Area
European North	10.2
Baltic States	0.6
Northwest	2.4
White Russia	0.5
Central	2.4
Ukraine and Crimea	0.5
Other Acquired Western Areas**	1.1
Upper Volga	1.2
Middle and Lower Volga	0.5
North Caucausus	0.5
Trans-Caucausus	0.5
Urals	4.5
Western Siberia	7.9
Eastern Siberia and Far East	60.9
Kazakhstan and Central Asia	6.3
USSR	100.0

* Estimated from E. Buchholz, "Die Forst und Holtzwirtschaft der Sowjet-Union nach dem Kriege," *Zeitschrift für Weltforstwirtschaft*, Band XII, Heft 1–3 (1948): 18, and Buchholz, *op. cit.*, pp. 13–14.

** Includes western White Russia, western Ukraine, Bukovina, Trans-Carpathian Ukraine, and Bessarabia.

[3] According to *Ost-Europa*, Volume 2, Heft 2 (April 1952): 126, the Soviet Minister of Forest Industries estimated that the total forest acreage in 1951 was 2,640,500,000 acres; the world figure according to *Unasylva*, I (July–August 1947): 27 was 9,019,150,000 acres so that by her own claim the USSR possesses approximately thirty per cent of the world's forest area.

[4] Erwin Buchholz, *Die Wald und Holzwirtschaft des Ostraumes* (Berlin, 1943) p. 20; in per cent the breakdown is as follows: larch 22, pine and stone pine 29, spruce 17, fir 6, deciduous 16 and 11 unknown.

[5] Due to the difficulty of floating these high specific gravity logs to the mills as well as pulping problems. However, there have been recent successful experiments in pulping larch in this country, and the Russians are also reported to be working on the problem. *Ibid*, p. 178.

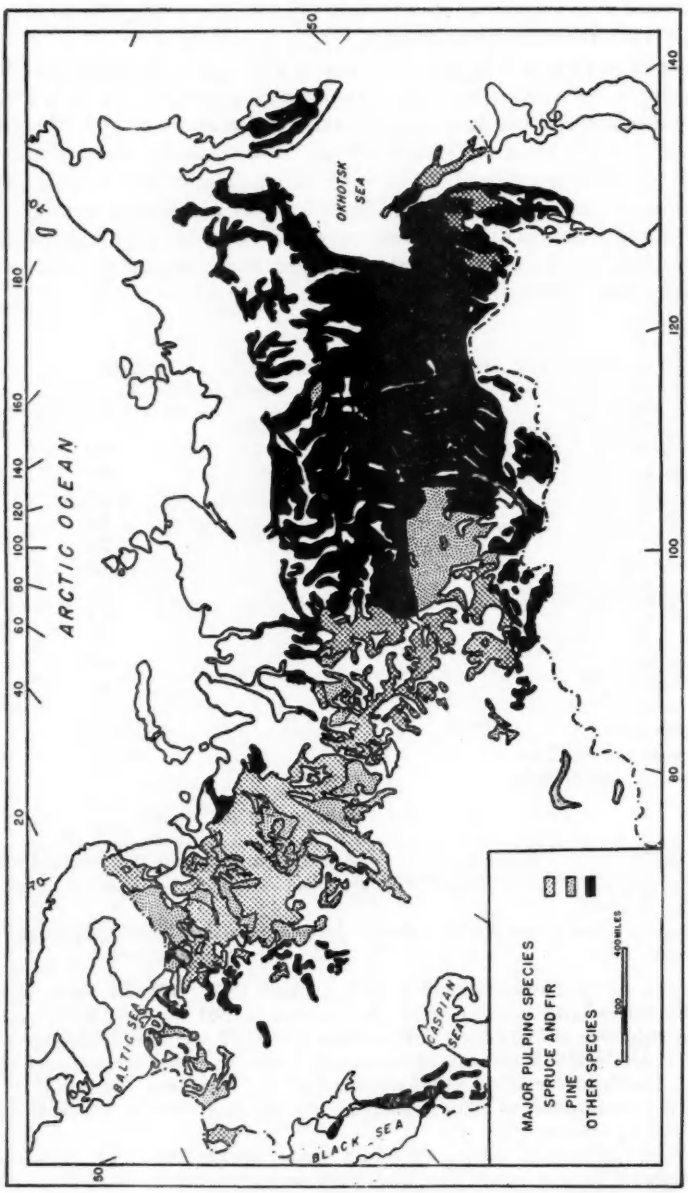

FIG. 1. Major pulpwood areas in the forest regions of the USSR.

Eastern Siberia alone contains over three-fifths of the nation's forest land while all of Asiatic Russia accounts for three-fourths of the total. These data are somewhat misleading, for they fail to take into account the greater accessibility of the forest areas of European Russia, and the better quality of the western stands. Not only are the European species of higher economic value, but the density of stands is very much greater than those in the east. Turning to the distribution of pulping species, Figure 1[6] shows a marked contrast with the overall pattern of Table III. With the exception of small areas in the Soviet Far East, the bulk of the usable pulping species are found in northern European Russia. Although the western Siberian area has a significant pulpwood supply it has only limited possibilities for major exploitation due to the presence of extensive swamps as well as the more ephemeral problem of accessibility. It should be stressed then, that while the bulk of the forest area of the USSR lies in Siberia and particularly in eastern Siberia, the major pulping species are found in the west. This in turn is one of the key factors in the concentration of Soviet pulp and paper industry in northern European Russia.

Other Cellulose Sources

Aside from waste paper, alternate sources of cellulose are of little consequence in the world paper industry. This has been especially true in the Soviet Union for, with the exception of a few small plants in the Ukraine and Central Asia which use local raw materials, the great bulk of the raw material needs of the industry have been provided by pulpwood. During the late thirties and especially in the post war period the Soviet press has stressed the need for utilization of local raw materials, such as straw from the various grains and technical crops, rush and reeds. However, in so far as can be ascertained, these materials still provide only a minor share of the needs of the industry.

One important difference between the Soviet paper industry and our own should be noted. In this country waste paper provides approximately one-third of the raw material needs of the paper industry. While no data on the consumption of waste paper in the USSR are available, the almost complete absence or avoidance of reference to this product in the Soviet literature makes it seem probably that with the great scarcity of paper in the Soviet Union, all paper is used to the maximum possible degree. A large share of the waste paper is presumably consumed for fuel, insulation, and repair and other household needs; consequently the available supply is very limited. As the economy matures and paper output increases, the importance of waste paper will undoubtedly increase.

CHANGING LOCATIONAL PATTERNS

The Tsarist Pattern

In 1913 paper production in Russia (within the 1939 boundaries of the USSR)

[6] Sources for compilation of Figure 1—N. Baranski, *Ekonomicheskaya Geografya SSSR* (Moscow, 1952): Figure 14; and S. Suslov, *Fizicheskaya Geografya SSSR* (Leningrad, 1947): Karta Rastitelnosti SSSR.

totaled almost a quarter of a million tons[7] (Fig. 2). This output came from a large number of small, mainly non-integrated[8] mills. The early paper industry was highly concentrated in the northwestern part of European Russia (the Northwest and White Russia—Fig. 3) with this region accounting for over sixty per cent of the nation's

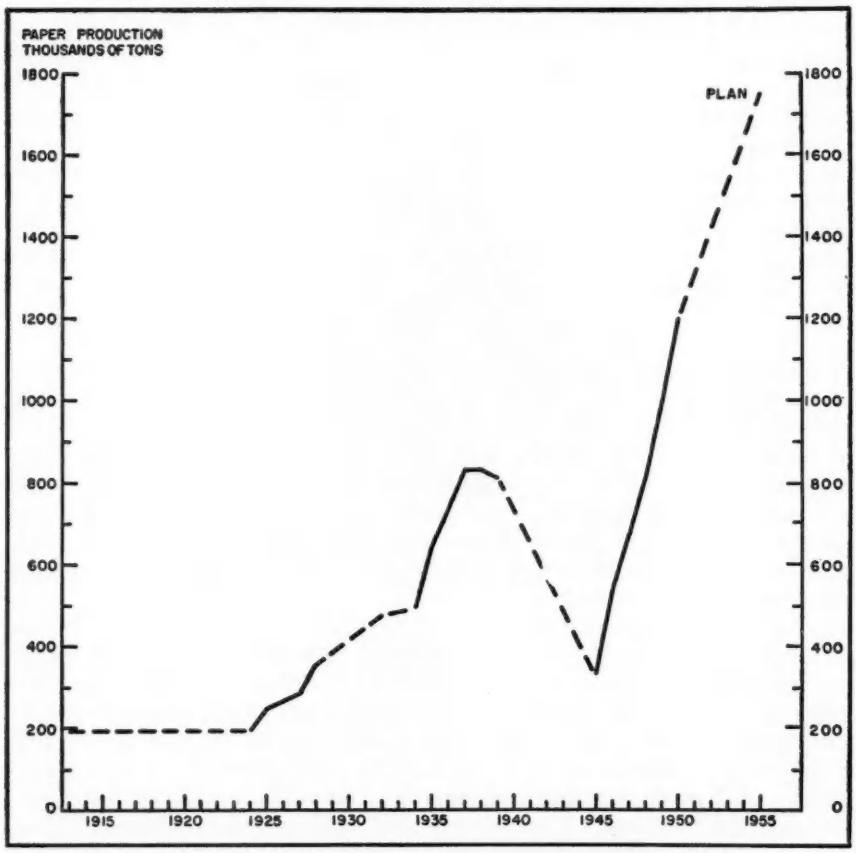

FIG. 2. Paper production (excluding cardboard) in the USSR, 1913–1955.

output[9]; Leningrad Oblast alone produced almost one-third of the total. The bulk of the remainder came from the Center and the South. It should be noted that as of this date there was no paper production in Siberia and Central Asia, while the forest

[7] G. Benenson, *Drevecina B Narodnom Khozyaistve* (Moscow, 1947) p. 53. Paper and cardboard production was 243,000 tons.

[8] Integrated mills are those that produce both pulp and paper.

[9] *Teknicheskaya Entsiklopediya SSSR* (Moscow, 1937) Second Edition, Volume II, p. 1220.

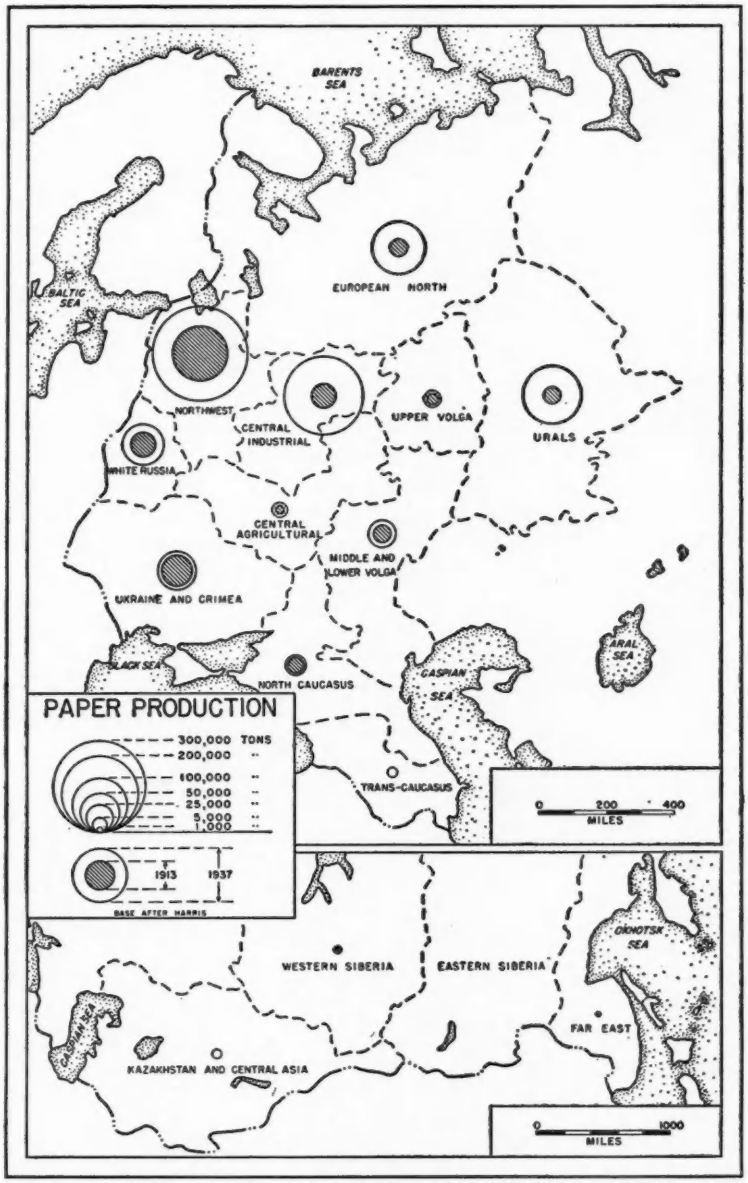

FIG. 3. Regional shifts in paper production in the USSR, 1913–1937.

areas of the North and the Urals district accounted for only a minor share of the total output.

Locational analysis.

The reasons for the concentration of production in the Northwest and particularly in the Leningrad area are complex. Perhaps the key factor in the location pattern was the relation of industry to the centers of forest cutting. In 1913 the bulk of the lumbering industry was centered in the areas north and northeast of Leningrad with secondary concentrations in the northwest. Thus paper plants located in and around this city could be assured of low cost pulpwood. In addition, since Leningrad was by far the most important lumber collection and export center, lumber destined for export as well as for distribution to other domestic markets was stored and transshipped from this point; therefore forest industries of all sorts arose in and around the city.[10] Another factor in the development of paper production in this area was inherent in the heavy reliance of the early industry on imports of semi-fabricated wood pulp. Although half of the raw material requirements of the paper industry came from rags,[11] largely of domestic origin, at least forty per cent of the wood pulp needs were imported,[12] mainly through the port of Leningrad. These imports were partly in exchange for pulpwood exports to western Europe, particularly to England and Germany. In addition Leningrad was the port of entry for foreign chemicals, paper machinery and spare parts, as well as for the foreign technicians needed to service the equipment. Not only was there an availability of material and personnel in this area, but capital, particularly foreign funds, was readily obtainable in this port and metropolitan center. The market factor also played a role in the development of the industry in the Northwest. Leningrad itself, as the capital and major administrative center of the nation, consumed large amounts of paper for various governmental purposes. On a larger scale, the Northwest, while not the center of heaviest population concentration in Tzarist Russia, was an important market area, and considering the location of sources of raw materials, the region was in an effective position for serving the populous central and southern consuming areas. Another factor that should be mentioned here is the availability of fuel and power of which tremendous amounts are used in the pulp and paper industry. Although the Northwest lacked and still lacks a local coal supply, there was an availability of cheap wood and peat fuels in the region, and in addition, Leningrad was the key entry point for imported British coal so that there was a supply of relatively low cost high grade fuel in the area as well.

The reasons for the virtual absence of paper production in the European North, the Urals district, and the east are less clear. Soviet writers have attributed the

[10] Thus in large measure the reasons for the development of many transfer points as industrial centers applies to Leningrad as well.

[11] The rag supply was, of course, closely related to the pattern of population distribution. Many areas which lacked adequate pulp resources like the Ukraine, parts of White Russia and the Center relied heavily on this raw material.

[12] Benenson, p. 53. In 1908 these imports amounted to about 26,000 tons of wood pulp.

overall concentration of industry in the west to a deliberate Tzarist policy of retarding the economic development of the so called "backward" areas. These "colonial" areas were to provide raw materials for the industries of the west and were also to

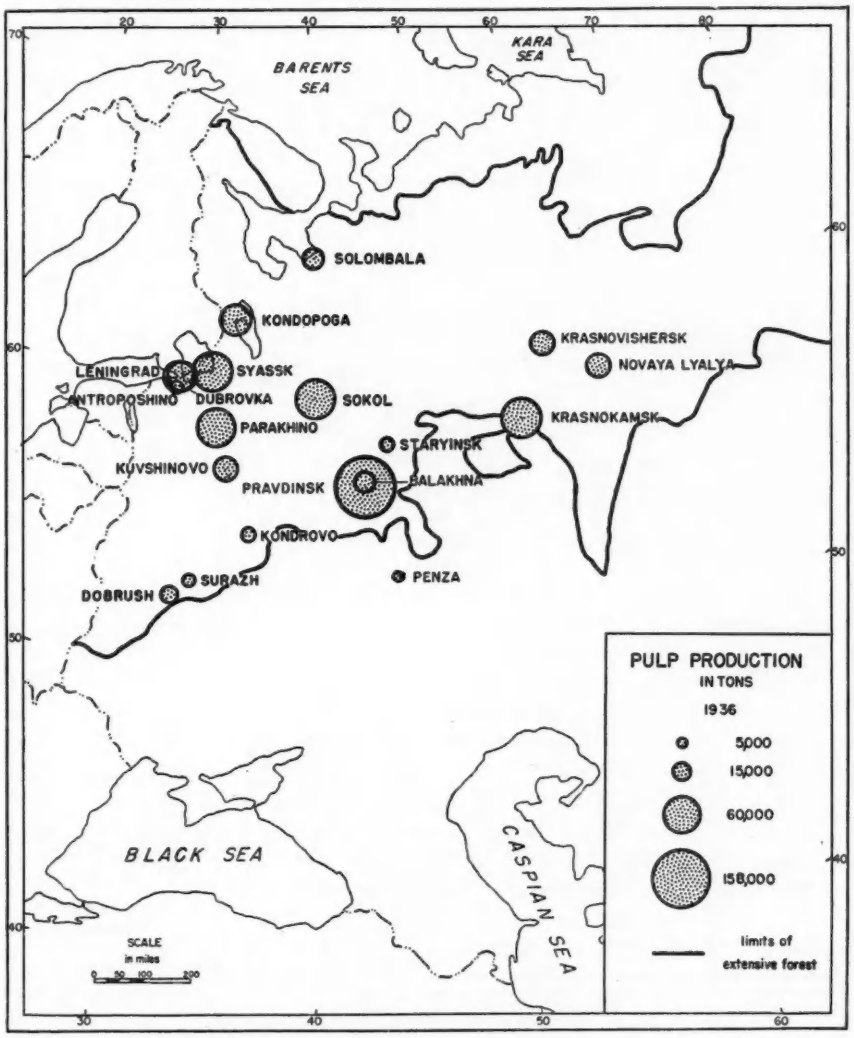

FIG. 4. Pulp producing centers in the USSR, 1936.

serve as markets for manufactured products. Certainly, such reasoning as applied to paper production, ignores the concentration of markets in the west and the rela-

tively undeveloped transportation net of the northern and eastern regions which in turn focussed forest cutting in the northwestern area.

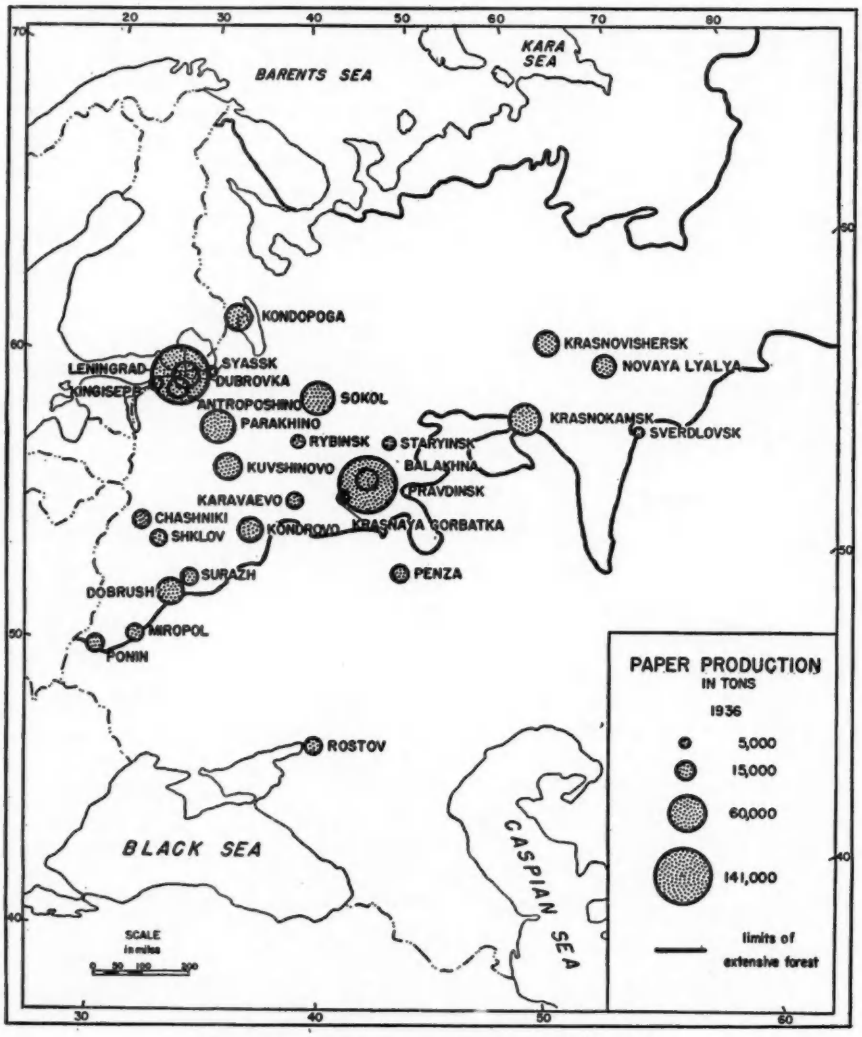

FIG. 5. Paper producing centers in the USSR, 1936.

The Pattern of the Middle Thirties

By 1937 paper output had surpassed a million tons. There had been two significant changes in the production pattern: the bulk of the output was now concen-

trated in a relatively small number of large integrated mills, and the industry was somewhat more dispersed than in Tsarist times. Figures 3, 4, and 5 illustrate the locational arrangements as of 1936–37. Over two-fifths of the paper output came from plants in the Northwest, almost one-fourth originated in the North and the Urals, approximately the same proportion in the Center, and practically all of the remainder in the South and Southeast. It is noteworthy that though production had risen significantly in the North, Urals, and Center, the largest segment of the industry was still in the Northwest, and there was no significant production in Siberia, Kazakhstan, Central Asia, or the Caucasus.

Locational analysis.

It seems apparent from the data presented in Figure 3 that although some dispersion had occurred in the industry, the basic locational arrangement was still largely a reflection of the Tzarist pattern. The question might logically be asked here, why should the locational pattern have changed? Though there is no simple answer to this question, it can only be viewed in the light of Soviet industrial location policy. Soviet planners have always emphasized the development of resources in the so-called "backward" areas. Each of these regions was, in so far as possible, to develop its own raw material base and eventually its own industrial structure as part of a program of regional self-sufficiency. One of the reasons for this policy, aside from the obvious one of resource development, was an attempt to reduce the load on the transportation system, which in the case of rail transport had become quite acute during the thirties. As far as the heavy industries are concerned, part of the basic motivation may have been the problem of military security. An analysis of the relationship between the locational pattern of paper production, its raw material supply and the markets for paper products provides some clues as to the fulfillment of the program of regional development in the industry.[13]

The key attractive force for plant location in the pulp and paper industry is the distribution of pulpwood supplies. This results from the fact that the manufacture of pulp is a weight losing operation in which for every two tons of pulpwood consumed less than a ton of pulp is produced. From Table IV it is apparent that there is a strong correlation between the areas of forest cutting and the centers of paper production; the relationship would be more pronounced if the data were confined to pulpwood cutting. Despite this correlation it is noteworthy that even as late as 1937 many significant sources of pulpwood such as those in the North, Western Siberia, and the Far East were not being effectively utilized. It should be stressed, how-

[13] Another locational element that should be mentioned here is the availability of fuel and power. While in the "west" the availability of power, particularly hydroelectric power, has been of major importance in the pattern of paper mill location, in the USSR, despite a high per unit of capacity power requirement (based on the greater importance of mechanical pulp), the use of cheap widespread fuels like peat and sub-bituminous coal has materially lessened the attractive force of water power sites (except in southern Karelia and Leningrad Oblast). Therefore, the location pattern of the industry is far more closely related to raw materials and markets than might be true elsewhere.

ever, that the attraction of the paper industry to the pulpwood cutting areas has been noticeably greater in the USSR than in the United States. The Soviet pattern is one of the integrated mills (note the correlation of Figs. 4 and 5), while an important share of this country's paper output is produced in non-integrated mills located in the consuming areas. The data in Table IV emphasize the disparity between the paper producing centers and the market. Thus the northwestern part of European Russia which contained only an eighth of the population of the Soviet Union provided more than half of the paper output. On the other hand, the South

TABLE IV

REGIONAL DISTRIBUTION OF POPULATION, FOREST CUTTING AND PAPER PRODUCTION

Region	Population* 1939 Per Cent	Forest Cutting** 1935 Per Cent	Paper Production*** 1937 Per Cent
European North	2.3	14.9	10.6
Northwest	7.2	16.6	34.1
White Russia	3.3	4.8	6.3
Central Industrial	12.9	12.7	24.0
Central Agricultural	8.8	0.4	0.8
Ukraine and Crimea	18.8	3.6	5.3
Upper Volga	4.7	8.4	0.9
Middle and Lower Volga	4.5	3.2	2.7
North Caucausus	6.1	1.2	1.6
Trans-Caucausus	4.7	3.6	0.3
Urals	7.2	16.0	13.0
Western Siberia	5.2	4.5	0.1
Eastern Siberia and Far East	4.5	9.5	0.0
Kazakhstan and Central Asia	9.8	0.6	0.3
USSR	100.0	100.0	100.0

* Balzak et al, *Economic Geography of the USSR* (New York, 1949): pp. 507–8 modified.

** W. Leimbach, *Die Sowjet Union* (Stuttgart, 1950): p. 296 modified. Total cutting 208.5 million cubic meters.

*** Compiled from P. Altgauzen and I. Shirov, "On the Geographic Distribution of Our Industry," *Bumazhnaya Promyshlennost* No. 5 (1941): 30 and V. Chuistov, "On the Development of the Paper Industry of the USSR, *Planovoye Khozyaistvo* No. 10 (1939): 68 and *Sotsialisticheskoe Stroitel'stvo SSSR* 1933–38 godu (Moscow, 1939): 71. Total paper production 1,017,000 tons.

with over one-third of the population had only about one-tenth of the paper production. Siberia, Kazakhstan, and Central Asia had essentially no paper output; yet these areas contained almost one-fifth of the people of the Union. In summary, then, although there had been some shift in paper production northward and eastward between 1913 and 1937, the marked disparity between the paper producing and consuming areas and the lack of utilization of pulpwood supplies in many of the outlying areas left a great deal still to be accomplished in the regional development

of the industry. The lack of more pronounced locational shifts can be attributed partially to the economic history of the twenties and early thirties. During this period only limited funds were available for construction of pulp and paper facilities; therefore the cheapest and simplest method of increasing production was through the expansion of existing plants rather than through the construction of new installations. Thus the only new centers created by 1932 were the Syassk cellulose plant, Kondopoga, Balakhna, and Krasnovishersk (Figs. 4 and 5), and these were only partially completed. Many of the reasons outlined earlier for the dominance of the northwest in paper production such as the location of centers of forest cutting, wood pulp imports via Leningrad, etc., were still operative as of this date. The factor of industrial inertia seems to have played its role as well.

During the Second Five Year Plan (1933–37) greater attention was paid to the expansion of production northward and eastward. Ambitious plans were laid for the construction of large integrated combines, each with an annual capacity totalling over one hundred thousand tons of paper, at such centers as Segezh, Archangel (Solombala), Kotlas, Volzhsk, Krasnokamsk, and Krasnoyarsk. However, in the implementation of these plans, the Soviets ran into unexpected difficulties. Construction of most of these facilities started in 1934, but as a result of inept planning and failure to recognize the problems of plant construction in the forested regions of the north and east, only one of these plants was in operation by 1937.

Some of the errors in planning can be ascribed to the general "giant mania" that flourished among Soviet planners during the thirties. Soviet authorities, like Chuistov,[14] indicated later that part of the capital outlay would have been more usefully invested in small plants of 5–10,000 tons capacity, some of them non-integrated mills using purchased pulp, and other integrated mills based on local raw materials like reeds and straw. Most of the planned installations were to be built in thinly populated, relatively inaccessible forested areas; yet transportation both road and rail was needed during the preliminary phase, for the receipt of necessary plant equipment, tractors, bull dozers, building materials, etc. as well as food and supplies for the labor force and later for the shipment of finished products. In addition, the low population density of these regions made it necessary to import construction workers as well as the plant operating force. Another factor in the extremely slow returns from these new operations was the lack of adequate surveys of the resources of the areas tributaries to the new plants with the result that many of them ran into problems of undesirable pulping species, poor stands, poor river transport, inadequate fuel supplies etc.

The Post-War Pattern

Despite destruction incurred during the last war in which over half of the industry was either destroyed or severely damaged,[15] Soviet paper production has risen markedly above pre-war levels. Its 1950 production of over one and a half

[14] Chuistov, *op. cit.*, p. 69.

[15] *Pulp and Paper Magazine of Canada* (December 1945) : 1034.

million tons was, however, less than ninety per cent of plan.[16] This rapid recovery can be largely attributed to acquisition of additional plants in the Baltic States, Karelia, and Sakhalin as well as reparations, particularly from Finland.

The post-war locational pattern is indicated in Figure 6 and Table V:

TABLE V

ESTIMATED REGIONAL PAPER PRODUCTION, 1937–1950

Region*	Per Cent of Production 1937	Per Cent of Production 1950**
Baltic States	...	6.0
European North	10.6	18.0
Northwest	40.4	27.0
Center	28.4	21.0
South and Southeast	7.2	6.0
Urals	13.0	13.0
Siberia and Central Asia	0.4	2.0
Far East	0.0	7.0
USSR	100.0	100.0

* See regional outlines on Figure 6.

** Rough estimates from fragmentary data in Soviet press.

1. Kaliningrad
2. Klaypeda
3. Sovetsk
4. Neman
5. Kaunas
6. Vilnius
7. Sloka
8. Pyarnu
9. Tyuri
10. Kekhra
11. Kingisepp
12. Antroposhino
13. Leningrad
14. Sovetsky
15. Svetogorsk
16. Priozersk
17. Sortovala
18. Lyaskelya
19. Pitkyranta
20. Syassk
21. Suoyarvi
22. Kondopoga
23. Segezh
24. Molotovsk
25. Solombala (Archangel)
26. Chashniki
27. Shklov
28. Surazh
29. Dobrush
30. Miropol
31. Ponin
32. Zhidechev
33. Rakhovo
34. Parakhino
35. Kuvshinovo
36. Kondrovo
37. Sokol
38. Balakhna
39. Pravdinsk
40. Penza
41. Kotlas
42. Lalsk
43. Siktivkar
44. Krasnovishersk
45. Novaya Lyalya
46. Solikamsk
47. Severny Kommunar
48. Zuyevka
49. Krasnokamsk
50. Volzhsk
51. Ufa
52. Rostov
53. Zugdidi
54. Tallin
55. Kirovo-Chepetski
56. Tashkent
57. Barnaul
58. Krasnoyarsk
59. Komsomolsk
60. Uglegorsk
61. Kholmsk
62. Poronaisk
63. Dolinsk
64. Yuzhno-Sakhalinsk
65. Korsakov
66. Dubrovka

[16] In 1947 the Minister of Cellulose and Paper was relieved after holding office only six months; his ministry had been severely criticized for failure to meet production goals—*Izvestia*, November 30, 1947. According to *Bumazhnaya Promyshlennost* No. 3, 1948, construction proceeded at a rapid pace, but production had lagged due to pulp and fuel supply problems, machinery breakdowns and other operating difficulties.

FIG. 6. Paper producing centers in the USSR, 1950.

Locational analysis.

Baltic States and Kaliningrad Oblast—With their acquisition of the Baltic States in 1939, the Soviets gained a forest area of over eight million acres, roughly three-fourth of which was covered by conifers (mainly pine and spruce) as well as other pulping species.[17] In addition, they acquired a number of small pulp and paper mills.[18] During the war large parts of the forests were burned out and cut over, and many of the mills were either destroyed or severely damaged. Since 1945 the industry has been rehabilitated, additional facilities acquired in the Kaliningrad area, and a number of new plants constructed. The most important centers of production are shown on Figure 6.[19] Because of forest destruction during the war and extensive cutting for settlement and agriculture in the past, available pulpwood supplies in the Baltic States are restricted and can only support a limited development. This region is estimated to account for six per cent of the paper output of the USSR with the bulk of the production centered in the coastal areas of Latvia and Estonia. A large share of the output is presumably sent to various deficit regions.

Northwest—Historically, the Northwest has been the leading center of paper production in Tzarist and Soviet Russia. Despite a major relative decline this area still produces over one-fourth of the nation's output. Its major handicap lies in a restricted pulpwood supply which must be obtained from the north. The greatest center of production is concentrated in the Leningrad area with major satellite centers at Dubrovsk, Syassk, Parakhino and Svetogorsk (formerly Enso), acquired from Finland in 1940. The region suffered great destruction during the war, but by 1950 it was operating at essentially prewar levels. It is possible that some of the smaller plants that were destroyed may not have been rebuilt, for emphasis has been placed on the reconstruction of the more important mills. The Northwest still provides a significant surplus for shipment southward and eastward.

European North—With a tenth of the forest area and a far higher percentage of the country's pulpwood resources coupled with reasonable rail accessibility, the European North offers the greatest possibility for future development of the Soviet paper industry. As evident from Table V this region has experienced a major increase in capacity since the middle thirties with the growth coming from several sources. The most important additions were derived as a result of the Russo-Finnish War of 1940. Within the territory ceded by Finland there was an estimated capacity of almost three hundred thousand tons of pulp and one hundred thousand tons of paper.[20] Although these facilities were destroyed or badly damaged during the war the Finns were forced, as part of the 1944 treaty, to turn over to the Soviet Union four hundred thousand tons of pulp capacity, forty thousand tons of paper

[17] *Unasylva*, Volume 4, No. 2 (April–June 1950): 86.

[18] *Bumaszhnaya Promyshlennost*, No. 10, 1940: 65–6 estimated prewar capacity 186,000 tons of pulp and 100,000 tons of paper concentrated mainly in the Tallin district of Estonia and around Riga in Latvia.

[19] Space limitations preclude a discussion of individual plants.

[20] *Bumazhnaya Promyshlennost*, No. 9, 1940: 46.

board facilities, and large amounts of pulpwood and semi-processed pulp, so that wartime losses were amply replaced. As a result of these acquisitions there are today seven large paper centers in the Karelian Isthmus, some of them with capacities of over 50,000 tons. Aside from these mills, prior to and since the war large integrated combines were constructed in other parts of the European North at such centers as Segezh and Archangel (Solombala) plus a number of less important plants at other locations shown on Figure 6. In the overview, this region is the fastest growing paper producing region in the USSR accounting for more than one-sixth of the nation's output. Part of its growth can be attributed to rapid expansion of rail facilities in the region in the last decade. The limited market of the area permits the shipment of the bulk of its product to other parts of European Russia.

Center—Forest resources in the Central region are very limited. Continued cutting for agricultural settlement, construction, mining, and industry plus the devastation of the last war have severely depleted its pulpwood supplies. Despite this deficiency, this region still accounts for over one-fifth of the total paper production of the USSR. The bulk of the output comes from two mills, the Balakhna plant at Pravdinsk and the Mari combine at Volshsk. In addition to these, there are a number of smaller, in some cases non-integrated, operations at various locations shown on Figure 6. It is noteworthy that aside from the Volzhsk mill no new major plants were constructed in this region since 1937. With its large population and heavy paper consumption, it seems probable that significant amounts of paper must be shipped from mills in the North, Northwest and possibly the Urals to supply deficits in the area.

South and Southwest—Paper production in this region has been limited by a lack of adequate pulpwood supplies, for the only suitable forest areas lie in the Caucausus and western Ukraine. Mills in this region are generally small with capacities of less than five thousand tons, and most of them were in operation before the thirties. The forested fringes of the Podolian Upland and the Carpathians on the west constitute the largest producing area; here in addition to the older mills of the northwestern Ukraine, several new plants have been constructed in forested areas acquired from Poland. The largest single mill is located in the western Caucausus at Zugdidi on the Inguri River; this plant and a small center at Rostov on the Don are the main producers in the Southwest. In the overview, despite plant additions in this area prior to and since the war, this region with its large population remains one of the major deficit areas of the USSR.

Urals—This region possesses approximately one-tenth of the coniferous pulpwood resources of the Soviet Union. Five of the six major plants are located on the western slopes of the Urals where the dominant forest association is spruce and fir. The sixth, Novaya Lyalya, is situated in the eastern pine forest. Large scale production in this area started in the thirties and by 1941 all of the major mills shown on Figure 6 were in operation. During the war this was the only major producing region in the unoccupied areas. In the postwar period production has expanded steadily in this region keeping pace with the nation's overall development.

The most important plants are located at Krasnokamsk (the largest in the USSR), Krasnovishersk, Solikamsk, Novaya Lyalya, Severni Kommunar, and Ufa. Heavy production in the Urals district coupled with the relatively low paper requirements of the area has permitted shipments of surplus products eastward into Siberia and westward to the Central region.

Siberia and Central Asia—Siberia, excluding the Far East, is estimated to contain about one-third of the pulpwood resources of the USSR. As has been indicated earlier the bulk of the usable species are found west of the Yemisey River. However, extensive utilization in this area has been handicapped by problems of accesibility, drainage, poor stands, etc. There are two paper mills in central Siberia, the largest at Krasnoyarsk on the Yenisey and the other at Barnaul on the Ob. Paper production in the region, almost two per cent of the nation's total, seems inadequate for its needs; deficiencies are probably supplied by shipments from the Urals and the Far East. Production in Soviet Central Asia, which is limited to one small plant at Tashkent, is restricted by a lack of forest reserves. Although some pulpwood is available from mountain forests the Soviets have stressed the importance of straw and reeds as the basis for future expansion of production.

Far East—Approximately one-tenth of the forest land of the USSR is located in the Soviet Far East. This includes about seven million acres in southern Sakhalin (Karafuto) acquired from the Japanese in 1945. About one-fourth of the stands are rated as pulping species, particularly spruce and fir, and these are mainly located in and near the Amur Valley and especially in the former Japanese territory. The most extensive paper development is located in the latter area where plants were taken over whose total capacity was rated in 1944 at a quarter of a million tons.[21] The Soviets have claimed that Japanese operations were extremely wasteful and that a large share of the pulpwood supplies within an economic radius of the mills was exhausted, which has restricted operations on the island. By 1946 at least six large mills were in operation, although reports indicate that they are not operating at anywhere near pre-war levels.[22] On the mainland, the only known mill is located at Komsomolsk on the Amur River. The combination of output from these mills should certainly be ample for the present needs of the region and probably provides an important surplus for distribution in other parts of Siberia.

The data presented in the preceding regional analysis and Table VI indicate the marked locational changes that have occurred in the pattern of Soviet paper productions since 1937. Although the bulk of these shifts were the result of the war and its aftermath, they reflect locational trends that were already in evidence in the late thirties. The paper industry has certainly been strengthened as a result of its acquisition of forest areas and plant facilities in the west and in southern Sakhalin; however, its future lies not in either of these areas but in the northern lands of European Russia and the Urals district. These regions possess not only

[21] *Paper Industry*, XXVIII (May 1946): 279, and *International Reference Service*, V, Part 6, No. 15 (July 1947) "Japan's Pulp and Paper Industry."

[22] *Bumazhnaya Promyshlennost*, No. 7, 1947, p. 3.

the nation's finest pulpwood supplies but also the prime factor of accessibility to the major markets of European Russia.

The failure of the older producing areas to gain appreciably in production is not solely a result of wartime destruction. It can be partially attributed to the deficient pulpwood resources of the region; for the market which is strongly concentrated in these areas cannot itself exert a sufficiently attractive force for a markedly increased development of the paper industry. With the passage of time an increasingly large share of the low grade paper requirements of the south and center will probably be supplied by mills in the northern forest areas. However, production of quality paper in non-integrated mills using purchased pulp from the north may become more important in the future. The development of paper production in Central Siberia and the Far East has resulted in a reduction of paper shipments from the west, yet significant output is sitll lacking in Kazakhstan, Central Asia and western Siberia. Of these, only the latter area offers any real prospect of major development, but even here, expansion is dependent on further development of rail transportation into the forest areas (the railroads now under construction were not designed for this purpose and for the most part pass to the south of the major pulpwood regions).

OUTLOOK

Soviet plans for the period 1950–1955 call for an expansion of forty-six per cent in paper output.[23] If this plan were to be fulfilled, paper production would rise to over two million tons annually; even the achievement of this goal would leave Soviet per capita consumption of paper at an extremely low level. Expansion of paper output is a necessity for the USSR in the light of increased needs of paper and cardboard in industrial production, distribution, and construction, and the nation's ambitious literacy program. In part future growth will come from an expansion at existing plants, but an important share will probably be forthcoming from new mills, the bulk of them to be constructed in northern European Russia and the Urals. The construction of new facilities will not in itself solve Russia's paper needs; for she still faces, incongruous as it may seem in the light of previous discussion, pulpwood supply problems which are of growing concern to Soviet planners. These arise mainly from the rapid drain on the better stands of pulpwood and the distance (from effective transportation) of many of the nation's best pulpwood resources. Some evidence of the acuteness of these problems can be seen in the fact that Soviet mills are now using low grade conifers with high resin content and topwood that was formerly used only for firewood.[24] Another element in the pulpwood supply problem is the constant failure of the forest cutting segment of the industry to meet its goals. Buchholz[25] has suggested that one factor that may ease this situation is the constantly declining use of firewood in the USSR and its replacement by other fuels; thus more wood will become available for industrial and other uses.

[23] *Pravda*, August 20, 1952: 1–3.

[24] *Unasylva*, III, No. 2 (March–April 1949): 89.

[25] Buchholz, *Zeitschrift für Weltforstwirtschaft, op. cit.*: 3.

In the overview, the future scope of paper production in the Soviet Union will depend not only on available pulpwood supplies but also on the amount of capital devoted to the industry. This is obviously dependent on her industrial investment policy and in turn on overall Soviet strategy.

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APPENDIX

Sources for Maps and Charts

Figure 2—Sources for paper production data:

1913, 1929, 1932, and 1937—*Sotsialisticheskoye Stroitel'stvo SSSR 1933-1938 godu* (Moscow 1939): 71;

1925–1928—*Consulate Report, Riga, Latvia,* "Russian Paper Industry" (October 23, 1931): 5;

1935—*Sotsialisticheskoye Stroitel'stvo SSSR 1936:* 912

1936—*Zeitschrift für Weltforstwirtschaft,* Volume 8, Heft 2 (November 1940): 160

1938—*Planovoye Khozyaistvo,* Number 10 (1939): 69

1940—*Pravda,* (April 12, 1946)

1945–1948—Bergson, Blackman, and Erlich, "Postwar Economic Reconstruction and Development in the USSR," *Annals of the American Academy of Political and Social Sciences* (May 1949): 56

1949–1950—*Bolshaya Sovetskaya Entsiklopediya,* Volume 6 (1951): 283

1955 Plan—*Pravda* (August 20, 1952): 3

Figure 3—Based on data in—*Teknicheskaya Entsiklopediya SSSR,* Second Edition, Volume II (1937): 1220, *Planovoye Khozyaistvo,* Number 10 (1939): 68, and *Sotsialisticheskoye Stroitel'stvo SSSR 1933–38 godu* (Moscow 1939): 71

Figure 4—Estimated from *Bumazhnaya Promyshlennost,* Number 1 (1936) and *Sotsialisticheskoye Stroitel'stvo SSSR 1933–1938 godu* (Moscow 1939): 71, and *Teknicheskaya Entsiklopediya SSSR,* Second Edition, Volume II (1937): 1220

Figure 5—Sources are the same as for Figure 4

Figure 6—Compiled and estimated from various Soviet sources

MUST GEOGRAPHERS APOLOGIZE?

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FROM time to time geographers here and there take to task members of their profession for their past "failures." They criticize those who decades ago expressed such enthusiasm for environmentalism as to have fostered the concept of determinism. They condemn those persons who years ago advanced the belief that the oceans separated rather than connected the continents. They challenge the philosophy of an earlier day which attributed to the location of England "in the center of the land hemisphere" much of its rise to greatness. They condemn geographers for not having directed students' attention to the significance of the polar areas and for their failure to have prepared years ago, wall maps drawn upon a polar projection.

Geographers supposedly have neglected the urban field. They have paid too little attention to cartography. Too much of their writings have been purely descriptive. Not enough of their investigations have focussed upon the comparative. Research for the purpose of discovering principles has been inadequate. Microgeography has been neglected. The applied aspects have been treated infrequently. The reader of this listing no doubt can add still other comments by geographers in derogation of the work of their colleagues.

If there is validity in all of these critical remarks it would seem offhand we are in a bad way—if they are unjustified we should not hesitate to take a stand. Is the status of the science of geography so tenuous after the many centuries during which it has evolved that we must apologize for its condition? Is there something wrong with the science or with the specialists or is it conceivable that geography may still be in a primitive stage with a long road ahead before it attains that maturity which will provide stability and confidence in its tenets? Is it possible that geographers themselves are putting forth exaggerated claims for the worth of their science?

As an argument in behalf of the weakness of the field some persons contrast it with the strength of the physical or biological sciences. Presumably these sciences approach much more closely, a degree of precision unknown to the geographer, more especially beyond the reach of the specialist in the human aspects of geography. Principles as yet are largely lacking in the geographic field. A look in retrospect belies the truth of the comparison with the other sciences in part at least. We well recall the time when physicists said that the harnessing of sub-atomic energy more than likely would never be possible. Chemists not so many years ago declared the number of the earth's elements to be fewer than the 100 known today.

These statements are not meant to minimize the work of non-geographers. The fact is that all of these fields present a considerable array of principles that seemingly will stand for an indefinite period. On the other hand, under recent conditions induced by war and general international unsettlement the physical sciences are

evolving in bewildering fashion. Many former "facts" are being toppled at a startling rate. The learning and subsequent unlearning sequences of events almost staggers the specialists themselves. Even so, chemists, physicists, biologists, geologists, and others in the physical realms operate with relative ease as compared with the geographer who must conjure with that variable—man. In much of their experimental work they can establish controls. They can perform a great many experiments in relatively short periods of time or repeat experiments many times without having to leave the laboratory and often without taking time from their experiments for other responsibilities. Not so with the geographer, whose laboratory is largely the vast open spaces. He must travel widely, a time consuming and very expensive performance. Nor can he control a given setting at his will. To repeat his "experimental" observations, he may have to travel thousands of miles to find substantially identical situations, if such repetitions occur at all.

The point which we are endeavoring to emphasize is the great difficulty under which the geographer operates and the need for him to recognize that he is not as far along as he may imagine himself to be. His is a field of exceptional difficulty, and one which conceivably can never attain such imposing heights as may be expected of physical geography alone. Treating as he does with the whole earth, he is still in need of an enormous amount of data. So great, indeed, that by the time he has collected information concerning the distribution of life over the earth's surface and its adjustment to its environment, conditions at the beginning of the collecting job will have changed and in many instances will have become valueless. He shall then be forced to start all over; and possibly be confronted with a similar circumstance invalidating the second round of data. Thus, the task of collecting is not only interminable; it seems almost futile.

Another great stumbling block to the derivation of laws or principles which should make possible prediction is man's inventive genius. This of course, in a sense is what the remarks we have just made imply. We may cite a simple case. Not many years ago, geographers declared with considerable assurance what the distribution of market gardens and truck farms must be with reference to centers of concentrated population. They limited market gardens to a radius of ten miles around the periphery of a city. This distance was as great as a horse could be expected to haul a load of produce to market and return home within a reasonable time. Moreover, the produce itself was of a highly perishable nature and required close proximity to its market. The truck farmer specializing in one or two, or possibly three, much less perishable commodities, the kind that could be readily stored without suffering deterioration, could ship by train at his convenience and therefore, could be located on cheaper land at distances upwards of fifty to one hundred miles from the market. His land could not be located at greater distances because of the sensitive relation between freight charges and a selling price which the public was willing to pay.

Today, this beautiful differentiation is no longer valid. Man has devised good roads, rapid means of transportation, and mechanical refrigeration in transit which

nullifies the factor of distance. Market gardens are hardly distinguishable from truck farms. Their locations may be anywhere that modern means of handling are available.

Another of hundreds of possible illustrations may be in order. Some forty years ago we tramped the length of the Mesabi Iron Range of Northeastern Minnesota asking the question, how long will the iron ore output continue. The answers ranged from "fifteen" to "one hundred years." Of course, these responses were largely guesses and furthermore different orders of guesses depending upon whether the "authorities" were thinking in terms of 60 per cent, 45 per cent, 30 per cent, or some other quality ore. Obviously, many of the guesses have already been proved wrong and perhaps ultimately all the others will be shown to have been mistaken. The discovery of foreign fields of high grade ore, portending possibly disastrous competition, frightened the Minnesotans. They undertook an investigation of ways and means to utilize their seemingly "inexhaustible" deposits of taconite, a 30 per cent ore. After years of effort the problem has been "solved." Investments of the mining companies apparently are safe for what they believe to be an indefinite period. The immediate economy of many local communities in northeastern Minnesota is out of danger, not to mention the well-being of the remainder of the state which has long benefited from the iron ore tax that has flowed into its treasury.

The future for geographers is not all darkness. We may hope the quest for a correct interpretation of the behavior of plant and animal life as distributed over the earth and in terms of their physical environment will enlist so many minds that in due course we shall have the facilities for gathering data quickly, for classifying them immediately, and for deriving such principles as so great an accumulation of observations might be expected to yield. The future of the science also demands an approach somewhat different from that currently followed in some quarters. Mere description of the landscape is not enough. Unfortunately, a considerable number of regional theses is primarily descriptive, or description plus a negligible amount of interpretation. We shall always remember a pertinent comment made some years ago by the late Dr. O. E. Baker upon the occasion of an examination of a candidate for the Master's degree. He asked "What is there about your thesis that a good journalist could not have done as well or even better than you have done?" The answer was obvious. And yet, in some respects the candidate was not at fault because geographers have not accumulated sufficient data to constitute a basis for the discovery of principles or laws with which new findings may be compared.

Not long ago[1] we pointed out this weakness in the status of geography. We challenged the philosophy held by some geographers that the essence of the science involves areal differentiation. To be sure one can describe two or more natural or cultural landscapes and point out their differences. But a sound interpretation of those differences without a standard of reference is not possible. Only the ac-

[1] E. Van Cleef, "Areal Differentiation and the Science of Geography," *Science*, CXV (June 13, 1952) No. 2998.

cumulation of data which ultimately reveals identical occurrences under identical circumstances can lead to the formulation of laws and subsequent accurate interpretations based upon comparative values. What we need then is more micro-studies or other appropriate approaches, not with a view at first toward explaining any differences but with the hope of finding a sufficient number of situations of like order which may lead to the establishment of laws. After this has been accomplished we shall be in a position to interpret regional observations because then we shall have a standard of reference for areal differentiation.

To attain the goal set forth here involves an herculean task. The work of many generations of geographers is still necessary merely to establish a foundation upon which further construction may take place. Geographers must observe every square inch of the earth's landscapes hoping to find enough repetitive cases to enable him to convert hypothesis into law. For this reason it would seem we need not apologize for our still primitive stage, if we will be frank to acknowledge our deficiencies. We need only confess that we are still evolving; that because an important part of our subject matter, the human, is highly variable, we have a much longer road ahead and a much more difficult one than that of our colleagues in the physical sciences. If we take this humble position, the world as a whole is more likely to view us and our work with greater charity and a higher regard.

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